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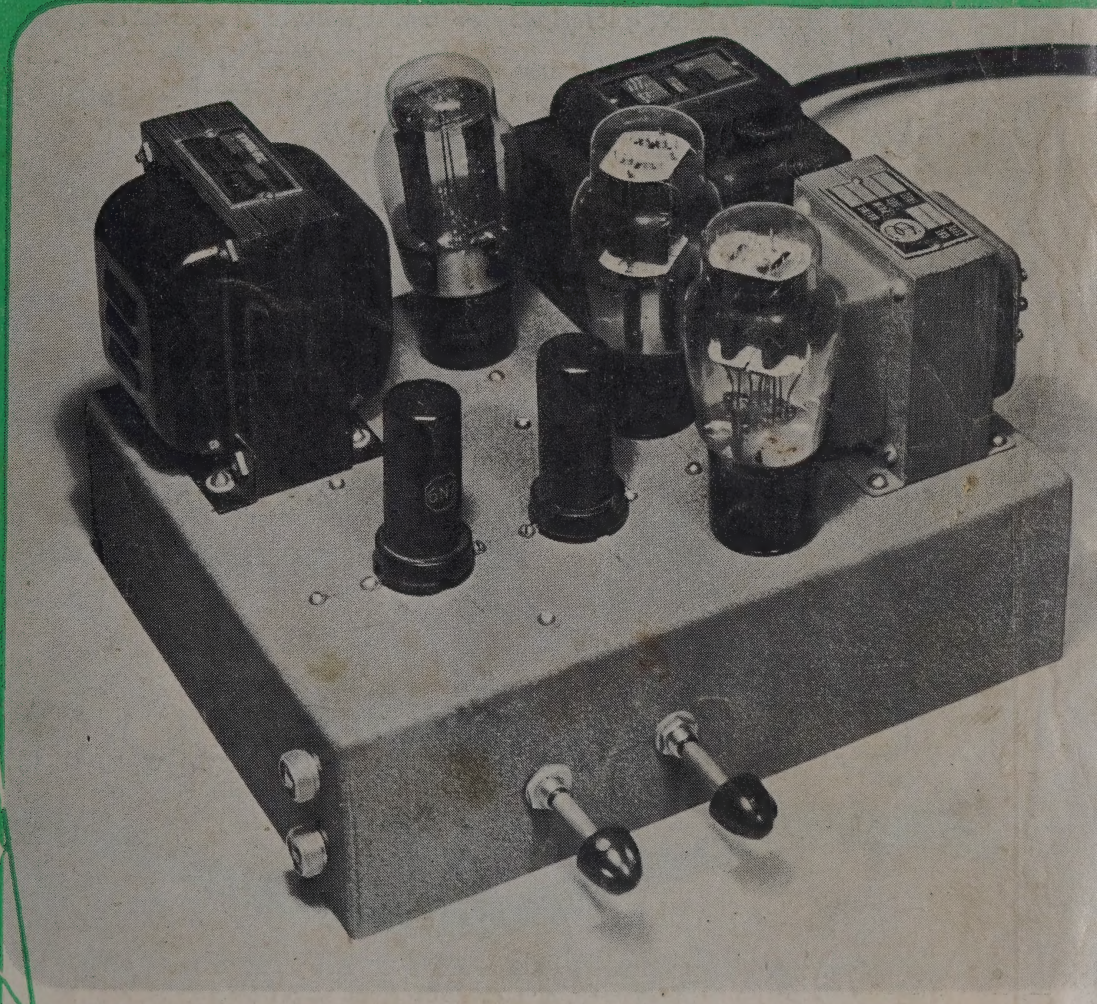

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RADIO and ELECTRONICS

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OUR COVER

This month's cover is an illustration of the new triode audio amplifier which is described on page 21 of this issue.

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GUY E. MILNE
ELECTRONIC TECHNICIAN

POWER CUTS & THE RADIO INDUSTRY

We are devoting this month's editorial space to a reprint of a statement on the above statement, made jointly a few days ago in the daily Press by the New Zealand Radio Manufacturers' Federation and the New Zealand Radio Traders' Federation. We had intended to write on this subject ourselves, but the excellent and cogent manner in which the statement puts the case made us feel that any efforts of our own would rather resemble an attempt to gild the lily. We have much pleasure in presenting the statement here, and wish to make grateful acknowledgment to the responsible bodies for their kind permission to reprint.

The New Zealand Manufacturers' Federation and the New Zealand Radio Traders' Federation refute the claims made recently by Mr. S. Blackley, spokesman for the Electric Power Boards and Supply Authorities' Association, that the curtailment of broadcasting would effect a big saving of electric power, and contend that the saving is in actual fact very small, as indicated by the following comparisons.

A radio set, irrespective of size, is the most economical household electrical device in constant use. On the average, it consumes no more power than a single medium-power lamp. By contrast, a single electric water-jug or iron or toaster consumes ten times as much power. An electric radiator or water-heater consumes 15 to 50 times more power.

Assuming there are 400,000 radio sets installed in New Zealand; that not more, probably less, than 250,000 are being used at any one time; that the average power consumed per set closely approximates 60 watts—the actual saving, based on the recently announced broadcasting restrictions, is only about 200,000 units per week. Thus the conservation of electricity is very small, and the national saving represents only 10 per cent. of the weekly consumption of the Hutt Valley Electric Power Board alone. This is a ridiculously small percentage of the 40,000,000 units which is the whole country's consumption, and is actually only one-half of 1 per cent.

A few days ago, Mr. Robinson, engineer-manager of the Hutt Valley Electric Power Board, was reported to have stated that the present cuts in broadcasting hours result in a 6 per cent. saving throughout the North Island, and that by cutting off an additional three broadcasting hours the saving would be another 1¼ per cent., and, furthermore, the closing down of the transmitting stations for the same period would increase the savings by a further 10 per cent.

It is authoritatively stated that the figures attributed to Mr. Robinson are so wide of the true position that it must be assumed that he has been gravely misreported. For instance, if all the broadcasting stations in the country were closed down for the period stated, the actual saving is only one-fiftieth of 1 per cent. of the country's total weekly consumption. The same amount of power could be saved by 8,000 owners of single-bar radiators switching them off one hour per week.

New Zealand radio manufacturers and retailers are very concerned that power authorities and highly qualified power engineers should persist, as they did last year, in using the radio industry as a "chopping-block." The power-saving achieved by the restrictions of broadcasting hours is so small that the cuts themselves must be classed as having nothing more than a "nuisance" value so far as the listening public is concerned.

The deplorable effect of the restrictions now operating is that the broadcasting cuts reflect so unfairly on a vigorous New Zealand industry, which has proved its efficiency in competition with overseas suppliers.

In factories, radio sets cannot be properly tested if no broadcasting station is available. Radio servicemen (many of whom are returned Servicemen) are unable to make full use of their skill and time in vital maintenance work.

Radio retailers on whom New Zealand factories rely for their output cannot demonstrate their wares to the buying public during the "cut" hours, and finally the cuts are so unfortunately timed as to prevent many would-be purchasers from hearing or choosing their sets during the only time many of them have available for that purpose. Thus the repercussions on the manufacturing industry may prove to be very serious. Evidence is available to show that during the cuts last year the volume of sales receded sharply. Manufacturers last year were kept busy catching up on their back-log of orders, but this year that will not be the case, and if a similar recession in sales is experienced it is likely that staffs will have to be reduced both in the manufacture and the distributing sections of the industry.

The result is the loss of factory efficiency and disproportionately increased costs. Who pays for it? As usual, the long-suffering public!

The radio industry desires to do everything in its power to conserve electricity, but it does object to being singled out and so unfairly attacked with misleading figures.

The industry has constructive suggestions to offer in aid of power conservation. For example, if broadcasting hours must be cut for what amount to psychological reasons, then let the cuts be only at the early and late ends of the broadcasting sessions, so that the very much heavier associated heating and lighting consumption is reduced thereby, achieving a really worth-while saving.

Let a national campaign commence immediately to make the public more conscious of the effective ways by which power can be saved. For instance, it would be true that if radiators were switched off each night for only five minutes each hour between the hours of 7 p.m. and 10 p.m., then the power so saved would be more than that saved by the present broadcasting "cuts."

Alternatively, if the power authorities switched off all water-heaters for 10 minutes only during the night, the power so saved would be equivalent to shutting down the broadcasting stations altogether, with its attendant radio set load.

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Atomic Energy—Engineering Problems in its Industrial Relation

By Dr. J. A. HUTCHESON, Associate Director, Westinghouse Research Laboratories

The jump from the realization of the atomic bomb to the idea of commercial use of fission energy is easy. But ahead of the actual accomplishment lies a vast, tangled, little-known jungle of problems. Some were suggested in the famous Smyth report, others were little anticipated. As we come closer to them, all become more formidable than was earlier believed. Confidence in the eventual outcome has not changed, but the concept of the size of the job definitely has.

No one questions that it is technically possible to achieve the controlled release of atomic energy in a form that can be converted into heat or electricity. However, before this is actually an accomplished fact, there is a great amount of work to be done. This work falls into two general classifications—namely, research and engineering development. At present there is under way in America a research programme, co-ordinated and directed by the Atomic Energy Commission, which, as time goes on, will uncover fundamental knowledge of this new science that is essential before industrial applications of atomic energy are practicable. Undoubtedly, therefore, as the store of available knowledge increases, there will come a time when answers to the many questions relating to practicability of atomic energy in industry can be determined with reasonable certainty.

That the application of atomic energy in industry will eventually be proved practical is assumed. What, then, are the engineering problems that must be solved before the first practical electric power generating station can be built?

The method by which a chain-reacting pile or nuclear-reactor operates has been discussed.* It is known, for example, that when a neutron, whose kinetic energy lies within a certain range, strikes the nucleus of a uranium-235 atom in such a way as to be absorbed, fission of the U-235 atom results. Products of that fission are two elements, each of substantially lower atomic weight, gamma-ray radiation, the discharge of one to three neutrons, and the release of extremely large amounts of energy. Further, some of the neutrons released eventually strike the nuclei of other U-235 atoms, whereupon the process is repeated, i.e., a chain reaction is established. However, the chances of a neutron striking the nucleus of another atom of U-235 are subject to several factors. Obviously, other kinds of atoms are present in a reactor. For example, there are those of the reactor coolant or heat-transfer medium, the structural material and surrounding shielding, those of the many control elements and devices essential to the operation of the reactor, as well as atoms of the many other elements that are the products of previous fission of U-235 atoms.

A few materials are partially "transparent" to neutrons. In some, such as carbon, absorption of a neutron is relatively unlikely. A neutron that enters such a material may collide with atoms of the material and be slowed up or lose part of its energy as a result, but in general it does not combine with these atoms and therefore is not absorbed. Again, the chances of absorption of a neutron depend in a complex way on the energy of a neutron. For example, it is much more likely that a neutron possessing an energy of a few tenths of an electron-volt will be absorbed by the nucleus of a U-235 atom with resultant fission than a neutron of a few hundred or more electron-volts energy.

These facts were employed in designing the reactors at Hanford, Washington. In these reactors, the fission produced neutrons released with high energy are slowed down by collisions with atoms of carbon in the moderator to the point that the average energy of the neutrons that re-enters the U-235 is most favourable to their absorption.

Most materials investigated show a marked tendency to absorb neutrons, a characteristic that disqualifies them for structural uses in reactors. This is dramatically demonstrated by the use of cadmium in control devices. Cadmium has such an affinity for neutrons that a very small amount stops completely the operation of a reactor. Cadmium absorbs enough neutrons to reduce the ratio of the number of neutrons available for fission, to the number of fissions required to maintain operation to less than one. When this occurs action ceases, since a single neutron can produce but one fission. Obviously such a material is useless as a structural material in a reactor. Unfortunately, the same is true of the common structural materials such as steel. This also explains why the materials must be of unusually high purity. The existence of impurities to the extent of a few parts per million in materials in which neutron absorption is relatively low makes these materials unsuitable for use in a reactor.

Similarly, the fact that the fission products act as neutron absorbers explains the necessity for removal of these products from time to time during continued operation of a reactor. As more and more of these products are formed, an increasing percentage of the available neutrons is absorbed. This requires a reduction in the amount of control material in the reactor. Ultimately there comes a time when this process cannot be continued, i.e., when all of the control material has been removed. Unless means are provided to remove "poisoned" charges during operation, the reactor must thereupon be shut down and the fuel charge replaced. In any power-generating application it seems essential, or at least highly desirable, that continuous operation be possible.

From considerations such as the foregoing, one type of engineering problem appears. Once complete information is obtained as to the neutron-absorption characteristics of materials, it will then be necessary to obtain the structural characteristics of those that appear applicable in reactors. This is an engineering problem that can and will be handled by engineers.

Another element that will require engineering consideration arises from the fact that the reactor will in all probability be required to operate at high temperatures, where heat engines are more efficient. This requirement creates additional problems for the

*"Physics Gives Us—Nuclear Engineering," by E. U. Condon, "Westinghouse Engineer, November, 1945, p. 167.

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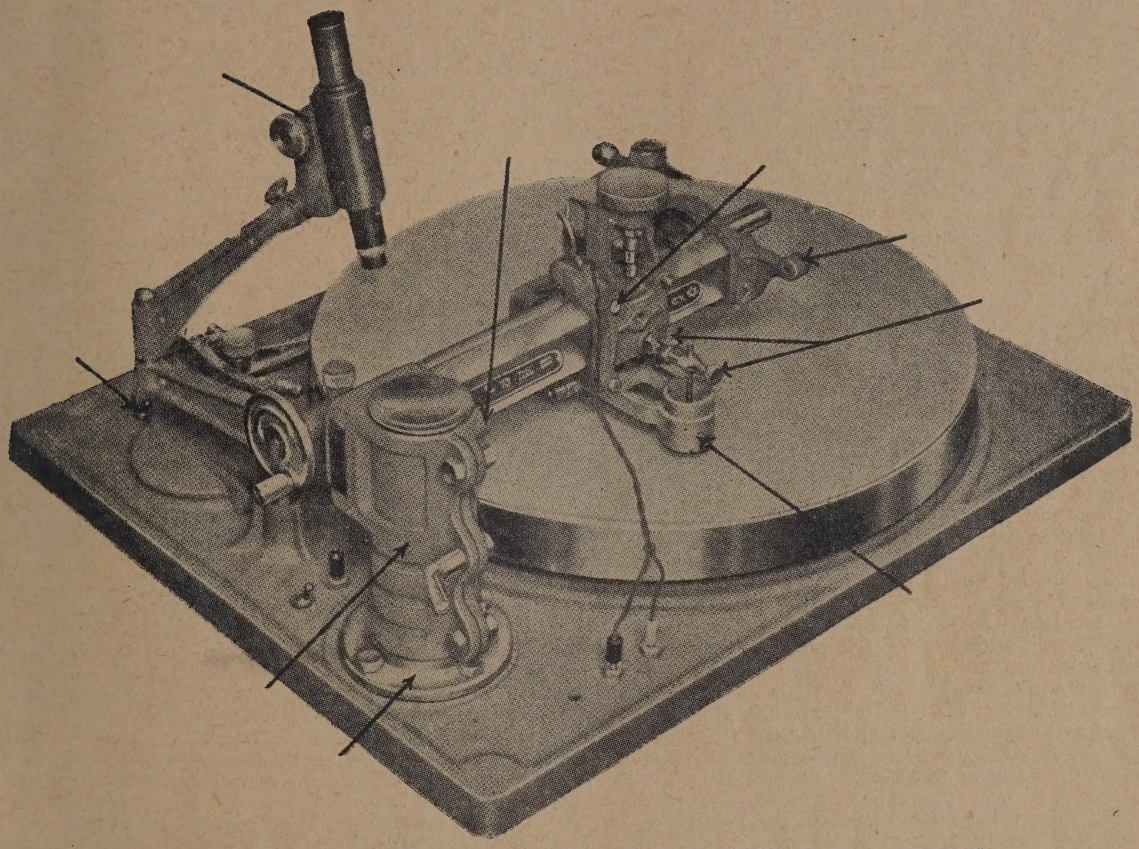

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engineer. For example, questions will arise as to the corrosion of materials subjected to high temperatures. Probably data must yet be obtained relative to the corrosive effect of various gases or liquids used as coolants or heat transfer media in contact with materials suitable for use within a reactor. These are typically engineering problems.

The high temperatures expected in power reactors introduce additional unknowns that must be determined prior to practical use. The mechanical properties, particularly at high temperatures, of those materials that now appear practical for use in construction of a reactor are largely unknown. Acquisition of the required data is possible by well-known methods, but the job is lengthy.

Radiations incident to the process of nuclear fission pose a large number of new problems for the engineer. The need for adequate shielding for operating personnel has been mentioned many times. This problem is more complex, however, than may be first realized. Consider, for example, the probable electric-power generating system. Heat generated in the reactor is transferred by a suitable gas to a heat exchanger in which water is boiled to produce steam for use with a conventional turbine generator. The possibility of leaks through which radioactive material might pass poses a serious problem. At first glance, it might be assumed that the only radiation problem is that concerned with the reactor. However, this is not the case. The gas coolant itself may become radioactive, and, in addition probably would gather other radioactive substances such as dust from the reactor. Presumably the heat transfer unit in which steam is formed is such as to prevent transfer of radioactivity to the steam by direct radiations. However, a leak would permit radioactive material to contaminate the steam. Depending on the magnitude of this effect, it might be necessary to shield the turbine and piping also. Obviously this is undesirable, therefore much engineering effort would be expended in assuring the absence of leaks.

Continuous operation of a nuclear power-generating equipment is desirable, if not essential. This means that the "fuel" must be replaced at intervals during operation. Because of the intense radiation within the reactor, extraction of the "ash" laden nuclear fuel can be accomplished only by remote control. The detail problems connected with the mechanical design of such devices are determined by the particular requirements of the reactor with which they would be associated. However, several general types of problems arise. Presumably the fuel will be distributed throughout the reactor, therefore the device must be so designed as to permit selection, removal, and replacement of fuel elements in any section. The device itself will be continuously bombarded by radiations so that it in turn becomes radioactive. This suggests the impracticality of servicing the device once it has been placed in operation. Trouble-free operation will require extreme care in design.

Factors such as the effect of radiation on lubricants are at present unknown. These must be determined prior to the use of lubricants with the equipment. Also, assuming that it will be found desirable to have electrical elements in the fuel-handling equipment, their reaction to radiations must be fully explored. For example, it would be fatal to use equipment in which the electrical insulation deteriorates under long-continued radiation bombardment to the point of failure.

Another matter is important, although little has been said regarding it. For many years radiations such as X-rays have been known to affect the properties of certain materials. For example, crystals of potassium chloride change colour under X-ray bombardment but return to normal upon removal of the radiation. Radiations within a nuclear reactor are many times more intense than any previously available. The possible effect of such radiations upon the crystal lattice of materials used in a reactor when exposed continually for long periods of time is yet to be determined. It is likely that the properties of materials will be altered sufficiently to bear on their suitability for use in a nuclear-energy reactor. This problem, if indeed there be one, rests squarely to-day in the hands of the research worker.

The foregoing has touched on some of the problems that become apparent when one considers the application of atomic energy to generation of electric power. Many will require additional knowledge, to be obtained by fundamental research work, before the engineer is able to tackle the design problems to be expected.

The speed with which these and other problems are solved depends, in a large measure on the number of men that can be applied to the work. Most of the fundamental work will have to be done by nuclear physicists and chemists working in government and industrial research laboratories. However, as these men progress with their work, many problems will arise that can be turned over to engineers and scientists not necessarily specialists in the field of nuclear physics. Members of the Atomic Energy Commission have recently stated their realization of this possibility and propose to take advantage of it. This is indeed encouraging. If the limited pool of nuclear physicists and chemists now available had to do all the work necessary for the practical application of nuclear energy in the electric power field, many years would pass before the first demonstration could be made. However, with a basic plan that envisions tapping the much larger supply of trained engineers and scientists available in industry and applying them to work on appropriate problems, it seems certain that the advent of nuclear energy in the electric power field is much nearer than otherwise.

As it stands to-day, comparatively little of man's store of knowledge is applicable toward hastening the day of controlled atomic energy. Handbooks and manuals chart and tabulate physical and chemical properties of the many available materials, metallic and non-metallic, under a variety of conditions of temperature, humidity, pressure, solvents, and so forth—but not under those expected in an atomic reactor. The immense task of measuring, recording, and tabulating these properties, with the additional variables of atomic conditions, may have to be done all over again; for some materials and some properties, it certainly shall.

There is indeed a big job to be done; so big, in fact, that one could not be blamed for being pessimistic about the possibility of a successful outcome. Perhaps the most optimistic note to be found lies in the fact that atomic energy is still a young science, not yet half a century old, and that knowledge of it is still meagre. So, then, man is not really in a good position to judge the future of atomic energy, its possibilities, its nearness, or the true value of appar-

(Concluded on page 46.)

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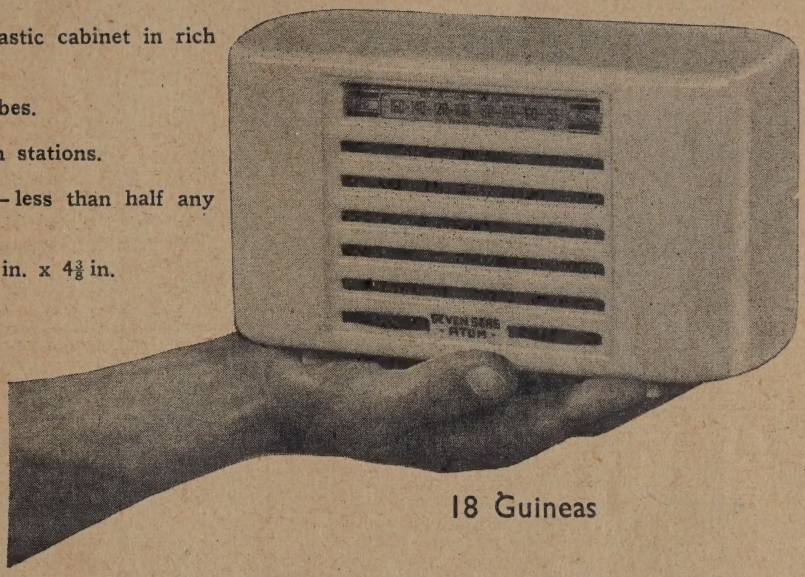

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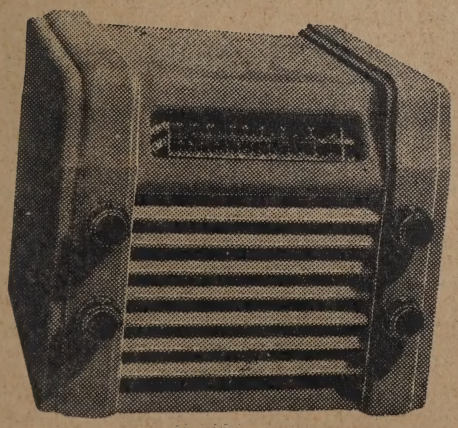

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PART 2

That the Q of coils and condensers, the R.F. resistance of resistors, and many other useful radio frequency quantities can all be measured on any reasonably good oscilloscope, with the addition of a small piece of auxiliary equipment is not widely known. This article discusses the principles involved, and describes how the above measurements can be made. A design is given for the necessary additional unit, and curves are provided which enable calculation to be dispensed with. Part 1 appeared in the May issue of "Radio and Electronics."

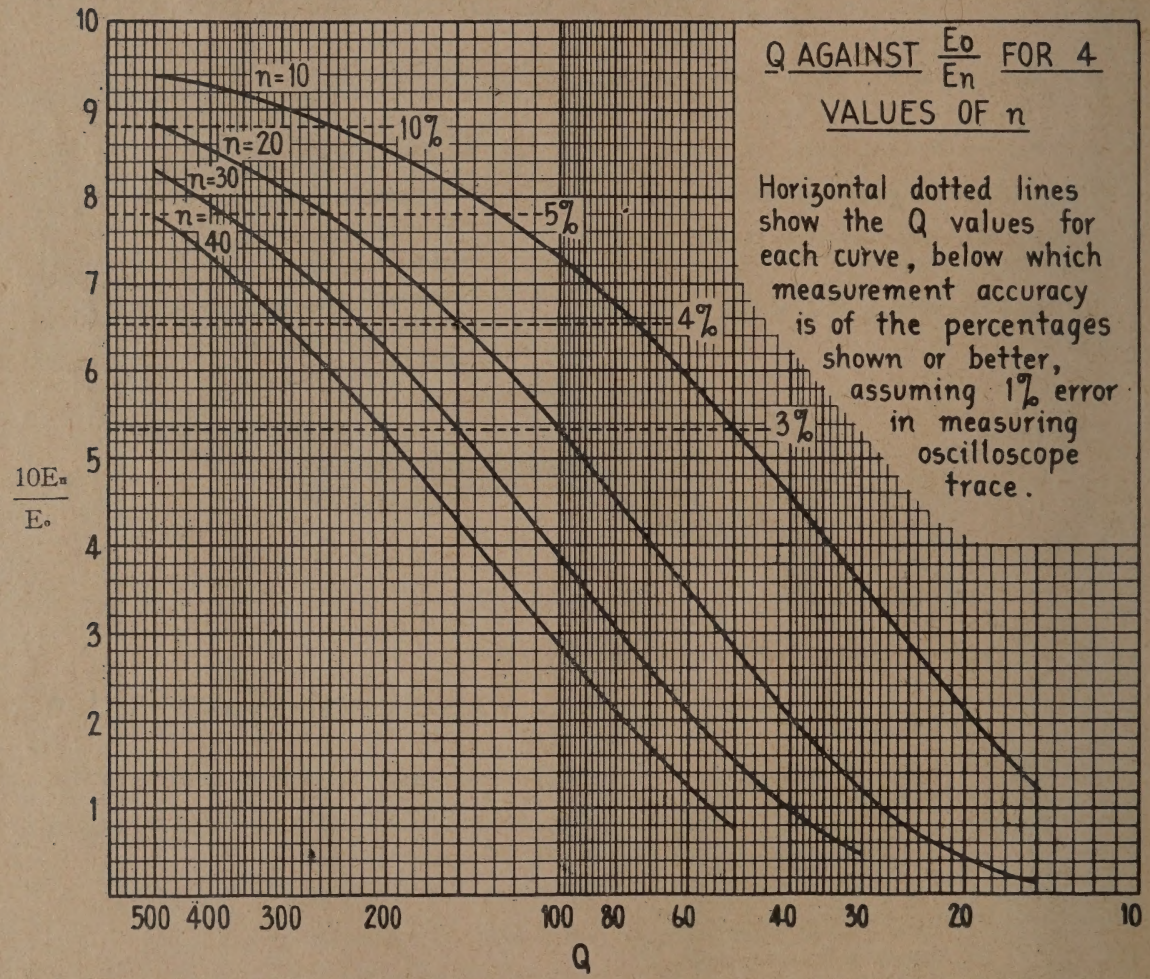

Fig. 6: This is the chart from which the Q of a coil can be read after measuring the 'scope picture as explained in the text. Please note that the title is incorrect, and should read 10En/Eo, as does the symbol beside the vertical scale. En and Eo can be measured in any units of length as long as the units are the same for both. For example, if Eo = 5.6 cm., and En = 3.4 cm., then 10En/Eo = 34/5.6 = 6.15, which is applied to the graph, and gives a Q of 130 if the cycles measured were 20 cycles apart.

OPERATION

Although there are a number of things for which the unit can be used, its primary purpose is that of measuring Q, so that we will describe its use for that purpose first.

(1) Finding the Q of a Coil

The coil is connected to terminals A and B. The jumper between B and C is connected, thus bringing C_7 into circuit. A wave-meter is then used to adjust the oscillation frequency to that desired for the meas-

urement. The output terminal is connected to the Y-plate of the oscilloscope, and the Synch Out terminal is connected to the Synch. terminal of the 'scope.

The set-up is now complete. The pulse frequency is now adjusted to a figure judged to be high enough in relation to the R.F., and the oscilloscope time-base is adjusted so that a single picture of the damped wave train is shown on the screen. The vertical amplitude is adjusted to a suitable value by means of R_4. A mark is made on the face of the C.R.T. indicating the cycle at which counting is to start. The amplitude of this half-cycle is measured, as shown in Fig. 2. The desired number of half-cycles is counted off, and the tenth, twentieth, or whatever number is being used, is marked and measured. The ratio of E_o to E_n is found from the two measurements and expressed as a number, the size of E_o being taken as 10. This figure is then applied to the appropriate curve of Fig. 6, and the Q of the circuit read off.

This procedure takes a long time to describe, but once a little experience has been gained, it should be possible to complete a measurement in a matter of half a minute or so after the system has been set up. In addition, there are one or two dodges whereby the process can be speeded up. For example, a mask can be made for the C.R.T. face, on which is drawn a series of horizontal lines. The bottom one can be made to coincide with the position of the undeflected trace, and when the H.T. is applied to the pulse unit, R_4 can be adjusted to make any particular half-cycle reach just to the top line, marked 10. The intermediate lines can be marked exactly as is the vertical scale of Fig. 6. Thus, when the amplitude of the cycle chosen for E_o has been set to the line marked 10, all that is necessary is to count to the cycle that has to be compared with E_o, and its amplitude read off the scale directly. Alternatively, or in addition, there can be on the mask two vertical lines at the right and left-hand extremities, and these can be used as markers for the cycles to be measured. The X gain control is then used to bring the $_n$th cycle to the right-hand vertical line, after the one representing E_o has been set to the left-hand one by means of the X shift control. However, for greatest accuracy, it is best to use a good rule marked in centimetres and tenths and measure the cycles with that.

We should point out at this stage that, although we have used as illustration the case where the first cycle of the train is used to represent E_o, this is not necessary, as any cycle can be used as a starting point. This is because of the fact, mentioned above, that the ratio of the amplitudes of successive cycles is constant, irrespective of which cycles are measured. Thus, one can start at any desired cycle in the train, measuring its amplitude and calling it E_o, after which the tenth, twentieth, thirtieth, or fortieth is measured and used in conjunction with Fig. 6 to find the Q of the circuit.

We will deal with the other purposes for which the damped train can be used in a further article, which will appear in a later issue.

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PREDICTIONS FOR THE WORKING OF LONG-RANGE RADIO CIRCUITS ON AMATEUR FREQUENCIES

JUNE, 1948

These frequencies are based on world charts of Maximum Usable Frequencies, prepared and issued by the Australian Radio Propagation Committee and supplied to "Radio and Electronics" by courtesy of this body and the New Zealand Department of Scientific and Industrial Research.

Contrary to normal commercial practice in the use of ionospheric predictions, the times given are derived from the Maximum Usable Frequencies, directly, and not from Optimum Working Frequencies, which are 15 per cent. lower.

The circuits are considered workable (a) if the band in question is below the M.U.F. at the time considered, and (b) if the said band is not lower than 65 per cent. of the M.U.F. If (b) is not satisfied, communication is unlikely, not because the frequency is not reflected by the ionosphere, but because the power available to amateurs is too low to overcome absorption in the ionosphere under these conditions.

Where the word "doubtful" appears in the tables, it indicates that between the times so labelled, the band is a little higher than the M.U.F. There is thus a possibility of effective communication on days when the actual M.U.F. is only slightly higher than that predicted.

All circuits have been assumed to start in Wellington. This creates the possibility of some slight error for other starting points, but this is of minor importance only, and does not justify the multiplication of the work involved.

ENGLAND

N.Z.D.S. Time

Wellington to Liverpool:

(a) North Route:
- 14 mc/sec. ..... 24 hrs.
- 30 mc/sec. ..... Nil

(b) South Route:
- 14 mc/sec. ..... 0630 — 2100
- 30 mc/sec. ..... Nil

U.S.A.

Wellington to New York:
- 14 mc/sec. ..... 0430 — 2000
- 30 mc/sec. ..... Nil

Wellington to New Orleans:
- 14 mc/sec. ..... 0430 — 2000
- 30 mc/sec. ..... 0600 — 1400

Wellington to Washington:
- 14 mc/sec. ..... 0430 — 2100
- 30 mc/sec. ..... 0600 — 1530

Wellington to San Diego:
- 14 mc/sec. ..... 0430 — 2100
- 30 mc/sec. ..... 0930 — 1530

CANAL ZONE AND SOUTH AMERICA

Wellington to Panama:
- 14 mc/sec. ..... 0430 — 1930
- 30 mc/sec. ..... 0600 — 1430

Wellington to Pernambuco:
- 14 mc/sec. ..... 0500 — 1930
- 30 mc/sec. ..... Nil

Wellington to Buenos Aires:
- 14 mc/sec. ..... 0500 — 1100
- 30 mc/sec. ..... Nil

AFRICA

(a) South Route:
- 14 mc/sec. ..... 0530 — 2030
- 30 mc/sec. ..... 1030 — 1330

(b) North Route:
- 14 mc/sec. ..... 0530 — 2230
- 30 mc/sec. ..... Nil

Wellington to Capetown:
- 14 mc/sec. ..... 0730 — 0830 (doubtful)
  1530 — 2230
- 30 mc/sec. ..... Nil

Wellington to Adan:
- 14 mc/sec. ..... 0730 — 2330
- 30 mc/sec. ..... 1330 — 1730

INDIA

Wellington to Karachi:
- 14 mc/sec. ..... 0730 — 2230
- 30 mc/sec. ..... 1230 — 1730

Wellington to Colombo:
- 14 mc/sec. ..... 0730 — 2230
- 30 mc/sec. ..... 1130 — 1730

Wellington to Calcutta:
- 14 mc/sec. ..... 0730 — 2230
- 30 mc/sec. ..... 1130 — 1730

ASIA

Wellington to Hong Kong:
- 14 mc/sec. ..... 0630 — 2130
- 30 mc/sec. ..... 0930 — 1530

Wellington to Singapore:
- 14 mc/sec. ..... 0800 — 2230
- 30 mc/sec. ..... 1000 — 1730

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A34	0.6	1.5	0.85"

Low capacity types	Cap. mmf/ft	Imp. ohms	Diam.
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C22	5.5	184	0.44"
C33	4.8	220	0.64"
Photocell Cable	10.2	132	0.36"

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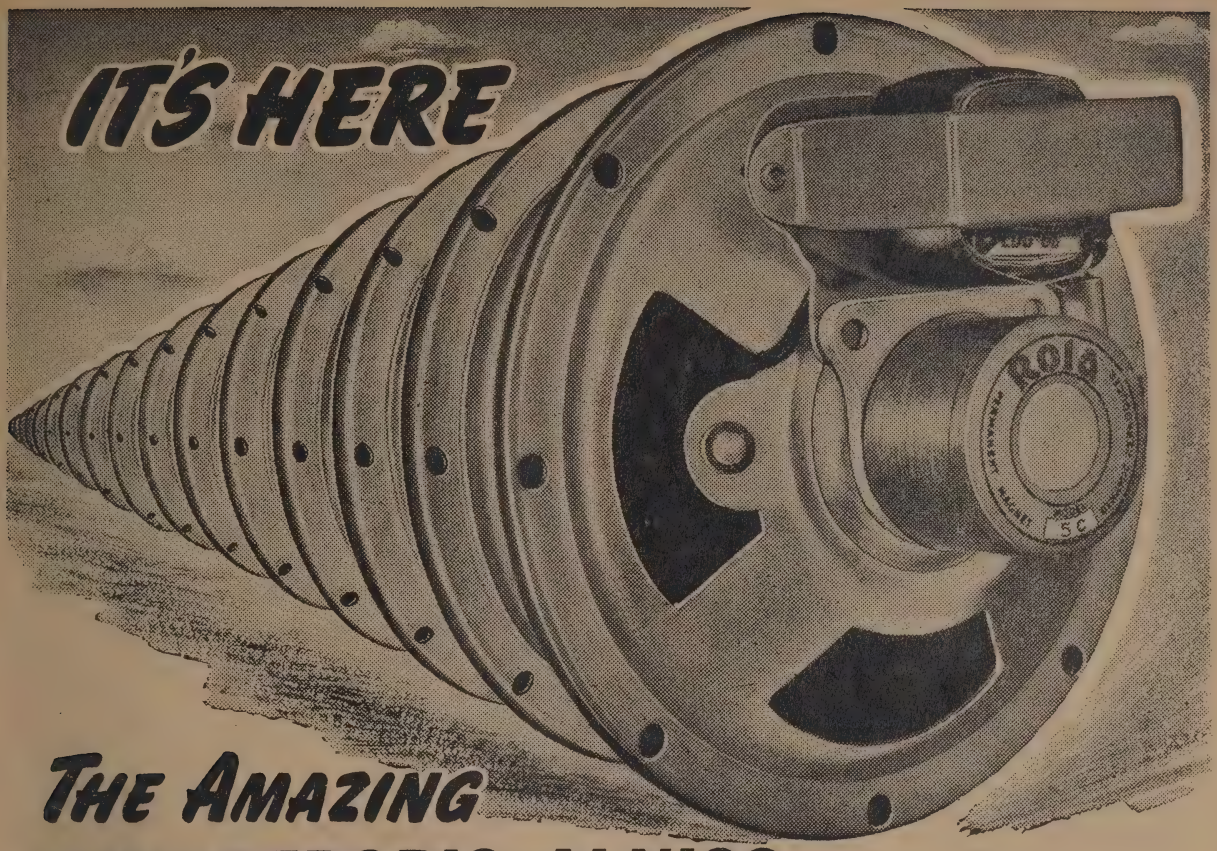

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QUESTIONS and ANSWERS

CORRECTION TO THE 3" OSCILLOSCOPE CIRCUIT WHICH APPEARED IN THE FEB., 1948, ISSUE OF "RADIO & ELECTRONICS"

A. J. C., Dunedin, writes to inquire whether the value of 150k. given in the circuit diagram of the above article is not a mistake. The answer is that it is a mistake, and should read 150 ohms.

USING HIGHER VOLTAGE ON THE "RADEL PORTABLE FIVE"

L.M.C., Oamaru, writes as follows:—"With reference to the 'Radel Portable Five' circuit which appeared in your Jan., 1948, issue, can you please advise me whether this circuit could operate with 90v. of H.T.? If not, what alterations would be necessary? I have built this set as originally published, and find that its performance compares very favourably with that of other portables—even those of larger design."

The set would not be satisfactory if 90v. were substituted for the existing 45 or 67.5v., unless some modification were made, but the necessary alterations are so slight that we will detail them here.

First, the back-bias resistor R_6 should be decreased to 400 ohms. Secondly (and this is most important if valve life and battery drain are to be preserved), the screen of the 1S4 output tube must have its voltage reduced to 67.5, which is the rated maximum for the type. This is best done by using a tap at this voltage on the "B" battery, but if this cannot be arranged, a dropping resistor of 15,000 ohms must be connected from H.T. plus to the screen of the 1S4, and an electrolytic condenser connected from screen to B —. This condenser can be 8 mfd. and can have any rating higher than 67.5v. The midget type of 8 mfd. 450v. condenser will probably be the easiest to obtain, and also to fit into the space available.

The screens of the 1T4's and the 1R5 will also have to be dropped to 67.5v. so as not to exceed their voltage ratings. First, a bypass condenser of 0.01 mfd. should be connected at the screen pins of the two 1T4's, and then a wire can be run connecting the two screens. A common dropping resistor of 7.5k. (two 1500-ohm ½-watt resistors in parallel) is connected from H.T. to the paralleled screens. The screen of the 1R5 requires different treatment, because it forms part of the oscillator circuit. In the diagram it will be seen that there is a connection between the screen and the "cold" end of the I.F. transformer primary. The junction then goes to the "hot" end of the oscillator coil's tickler. The first-mentioned of these connections is broken and replaced by a 0.0005 mfd. mica condenser. This preserves the connection as far as R.F. is concerned, so that the screen dropping resistor is now connected across the condenser to complete the D.C. circuit, and at the same time to drop the voltage to the screen. This resistor should have a value of 7k., but 7.5k. will not affect the performance, and can be made up similarly to that for the 1T4 screens. The modifications are now complete, and 90v. of H.T. can now be used, and will result in greatly increased power output, and somewhat higher sensitivity, due to the higher mutual conductance of all the tubes with the higher voltage. Of course, one must pay for all this by way of increased current drain, but on local signals this should be only 10 ma. or so.

THE HIGH-GAIN LOW-NOISE PREAMPLIFIER

A.E.B., Matakohe, North Auckland, writes:—"I am constructing the High-Gain, Low-Noise Preamplifier, using 6AC7's, described in the August, 1947, issue of 'Radio and Electronics,' but notice what appears to be a discrepancy in the script, where it deals with the placement of the valve socket with relation to the shield partition.

"The script says that the keyway in the socket faces right, so that the shield passes between pins 8 and 1 and 4 and 5, so that pins 1 to 4 are in the front compartment, and pins 5 to 8 are in the back one. This is quite correct, so far. Then it says that the input pins (grid and cathode) fall inside the front compartment, with the plate and screen pins in the rear one. It appears to me that the socket should be oriented so that the shield passes between pins 1 and 2, and 5 and 6. This would bring the cathode terminal in front, with the grid pin, and put the No. 1 or shield pin in the rear. I would be pleased if you could explain, as the point may or may not be important in such a high-gain stage."

The mistake in the script consists in saying that placing the socket in the described position brings the cathode pin into the same compartment as the grid pin. Since the cathode is bypassed to earth, it is not of much consequence whether the cathode pin is in the grid or plate compartment. As far as performance is concerned, either method of mounting the socket should be satisfactory, as long as the usual precautions are observed regarding the making of short connections and the returning of all "earths" to the same point on the chassis.

MODIFYING THE "RADIO & ELECTRONICS" 5" SERVICE OSCILLOSCOPE TO USE THE "HARD-VALVE LINEAR TIME-BASE"

G.G.S., Auckland, writes:—"The subject of my inquiry is the improvement of your 5" oscilloscope (published in the May, 1946, issue) by replacing the original 'transitron' time-base oscillator with the multivibrator time-base described in the April, 1948, issue of 'R. & E.'

"I have come to a number of conclusions regarding the change, but being unable to verify them, I would be very grateful if you could examine them for me. They are as follows:—

"(1) The full H.T. voltage from the low-voltage power supply can be applied to the new time-base circuit without circuit alteration.

"(2) No decoupling is necessary in the plate circuit.

"(3) The output of the time-base cathode-follower is suitable for direct connection to SW_2 of the oscilloscope circuit.

"(4) The moving contact of the potentiometer R_{10} in the new time-base circuit may be connected to C_{30} at the input to the oscilloscope blanking tube.

"(5) Synch. input to the time-base may be taken from the junction of R_{24} and R_{26} in the oscilloscope circuit (R_{26} being a fixed resistor) through C_{33} to the top of R_{11} on the new time-base circuit. Or should R_{11} be fixed and R_{26} be variable?"

In commenting on these statements we will take them in order.

(1) Since the circuit conditions for the two multivibrator valves are identical, with the exception of the grid time-constants, the plate current sum for V_1 and V_2 should be constant, although the AVERAGE plate-current of V_1 is about ten times that of V_2. However, some decoupling (with automatic voltage dropping as well) will have two beneficial effects. In the first place, the time-base circuit needs a well-smoothed H.T. supply, since any hum will tend to cause multiple traces to appear, and therefore will give a fuzzy trace that looks as though the C.R.T. will not focus properly. Secondly, keeping the plate voltage on the 6AC7's down to their recommended maximum of 300 (which value is reached when they are in the non-conducting state) helps to prolong tube life. The decoupling resistor can usefully be placed in the H.T. feed to all three valves in the time-base circuit, and its value adjusted until the voltage on the circuit has the recommended value of 300v. An 8 mfd. electrolytic condenser paralleled by a 0.001 mfd. mica condenser should be used across the time-base circuit, from H.T. to earth.

(2) This has been answered above in the answer to question (1).

(3) Yes.

(4) Yes, because the pulse corresponding to the fly-back period, found at the plate of V_1 in the time-base is positive-going, and must be reversed in phase before being applied to the C.R.T. grid.

(5) It is preferable to keep R_{11} in the time-base circuit as the variable element, since only a very small synch. voltage is needed, and because doing so ensures that there is usually only a small resistance in the suppressor circuit of V_1. Doing things the other way about keeps a high resistance permanently in circuit with this suppressor, and may tend to make the time-base not self-starting.

USING THE 6AC7 AS AN R.F. AMPLIFIER

M.R.M., Auckland, writes, saying that he is interested in using a 6AC7 as an R.F. amplifier on account of its low noise-level, but has been discouraged by our statements to the effect that there are difficulties in so doing. "What," he asks, "are the difficulties, and can I come to some compromise with the tube that will enable me to use it?"

In the first place, the 6AC7 is a sharp cut-off tube, i.e., it has not got a variable mu characteristic. This makes it almost impossible to use it on the broadcast band, at least in normal circuits where A.V.C. is used on the R.F. stage. Unless the set is to be used in a locality where there are no strong local signals, this means that a manual gain control must be added to the circuit, and this is a feature with which a good many people are by no means disposed to put up, but is one of the features through which a compromise can be made. This manual control should take the form of a variable screen voltage, giving a range of zero to 150v. It should be realised that by having an R.F. stage to which no A.V.C. is applied, the overall A.V.C. performance of the receiver is materially reduced.

Secondly, the exceedingly high mutual conductance of the 6AC7 makes it a difficult matter to render the set absolutely stable. The normal type of construction where a top-cap grid connection on the R.F. tube is relied upon to isolate the grid and plate circuits of

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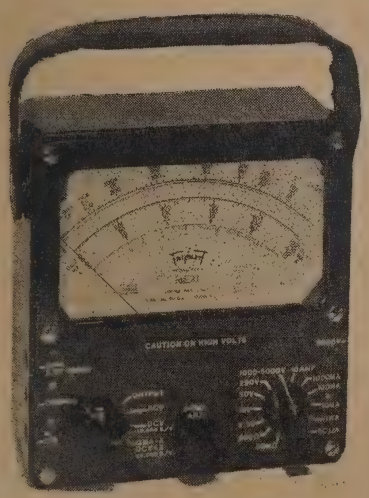

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the valve cannot be used, and unless very complete shielding of the stage is employed, the chances are that it will not be possible to make the set "sit down" properly. Extra gain, if it results in instability, is a good deal worse than useless. Also, if regeneration is present, the low-noise properties of the R.F. stage are apt to be completely nullified. High Gm tubes such as this were never intended to be used at broadcast and low short-wave frequencies. At these frequencies the tuned circuits can be made with such high dynamic impedances that when a high Gm tube is connected in an amplifier circuit, the stage gain is so high that normal shielding methods will not prevent instability, even when all possible decoupling and wiring precautions have been taken. It is this fact which can cause difficulty of this sort in applying the 6AC7.

In the case of a separate unit, such as a pre-selector, which can have shielded input and output leads, the tube is more tractable, but even so great care must be taken to see that the input and output circuits are well shielded from each other, and that the proper precautions with regard to earthing are observed. For example, the pre-amplifier described in "R. & E." for August, 1947, was built along these lines, and gave no trouble of this sort. Perhaps the best answer is to build the receiver with a normal R.F. stage, and use a separate unit for the 6AC7, which can be switched out of circuit when its use is not necessary.

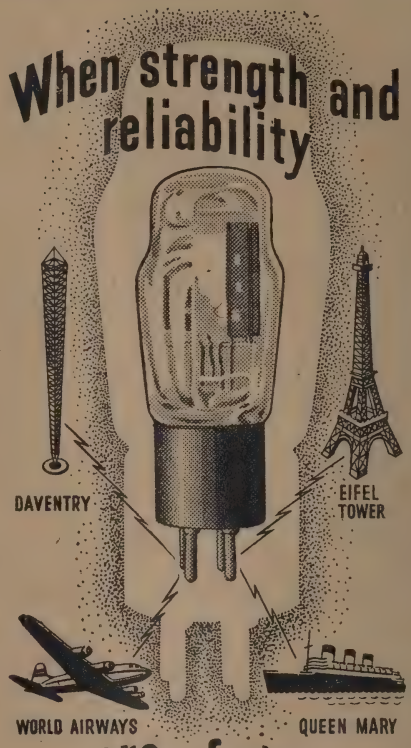
OSCILLATION WITH THE "RADEL PORTABLE FIVE"

A.McG., Christchurch, writes that he is troubled with oscillation which occurs only when the set is tuned to a strong local signal, or if an external aerial is attached to the set. From the symptoms described, it appears as though the trouble might be due to I.F. getting into the audio amplifier. The purpose of the condenser, C_{14}, connected across the primary of the output transformer is to prevent I.F. voltage from developing to too high a level in the plate circuit of the output stage, and hence from radiating back to the early part of the set. The correct procedure in effecting a cure is to try various values for C_{14}, somewhat larger than that specified in the circuit, and find the smallest condenser that will cure the trouble. If our diagnosis is incorrect, then no value, unless much too large for adequate high note response, will do much good.

It should be pointed out, in fairness to our own design, that A.McG. has not used the lay-out of parts suggested by us, so that the instability may possibly be due to this fact. From a sketch supplied by him, we find that the early part of the circuit is arranged as follows:—Gang condenser at one end of a narrow chassis, then, next to it the oscillator coil, and after this the R.F. tube and the mixer valve, in that order.

This arrangement is open to criticism on general grounds, for the lead from the R.F. stage grid is necessarily long, and could easily cause the R.F. stage to be unstable. It would have been better to place the gang as close as possible to the R.F. tube. If any leads have to be long, the least important ones are those to the oscillator coil. Radiation from these leads cannot cause instability, since the oscillator is never tuned to the signal frequency. Another bad

(Continued on page 46.)



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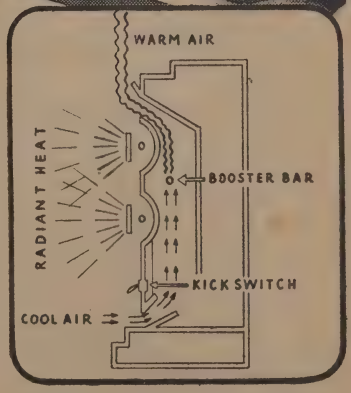

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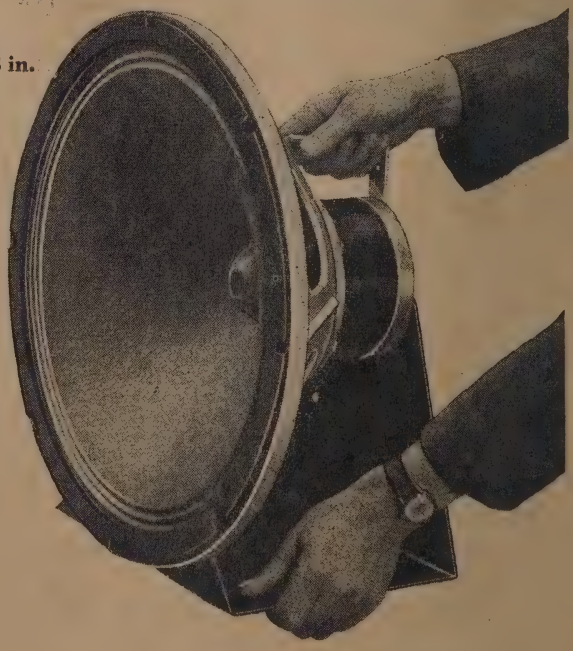

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Some Notes on High-frequency Oscillators

Now that amateur transmitting enthusiasts have allotted to them bands up to frequencies much higher than can be attained by the use of conventional valves, many must be asking themselves questions that are not answered in the valve manuals, such as "How high will such-and-such a tube go as an oscillator?" An obvious retort to such a query is "Try it and find out!", but this is a fairly unsatisfactory answer to one who has only a limited amount of time available in which to perform lengthy experiments, and who is probably more interested in the construction and operation of gear for the higher frequency bands, rather than in designing such equipment from scratch.

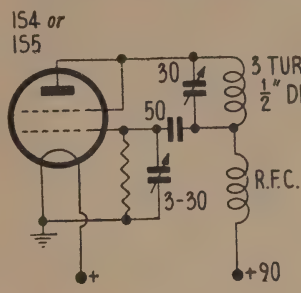
With this idea in view, we have prepared this short article. It does not purport to be exhaustive, in any direction at all, but sets out to help those who may wish to do some experimental work on oscillators for themselves, and have not much idea of how or where to start.

MINIATURE BATTERY TUBES

As a good example of valves about which there is a complete dearth of information, except on how to use them in circuits and at frequencies for which they were originally designed, we have chosen two of the now well-known 1.4v. miniature battery series, namely, the 1S4 and 1S5. There are several other reasons for this choice. In the first place, since the V.H.F. bands are suited only to line-of-sight transmission, except for anomalous conditions, many amateurs are precluded by their localities from any but portable or transportable work on them. For this purpose, equipment operating wholly or in part from dry batteries is convenient, and in these days of miniature batteries, light. Also, the shortness of the aerials required and the very low power that suffices for line-of-sight operation are both incentives to attempts at something after the "walkie-talkie" and "handie-talkie" style of thing. All these points indicate that if the 1.4v. miniatures could be used, they would have many advantages.

CIRCUITS FOR OSCILLATORS

Suppose we wish to start right from scratch and find out how high in frequency the 1S4 and 1S5 will oscillate, and whether at their limits they can be used in practical circuits. The first and most obvious question to ask before making a start is "What will be the best circuit to use?" When one thinks of the innumerable circuits that are used at lower frequencies, this is apt to prove a stalemate unless one has definite ideas on the subject beforehand. In the July, 1945, issue of the Proceedings of the Institute of Radio Engineers, there is to be found an excellent article entitled "Wide-range Tuned Circuits and Oscillators for High Frequencies." This deals, in the main, with some of the latest developments in the physical form of tuned circuit elements, and has an excellent description of butterfly and cylinder circuits. These represent considerable advances in technique for frequencies above 150 mc/sec. and enable phenomenally high Q to be obtained at frequencies up to 1100 mc/sec. or so. However, our primary interest was in seeing how our chosen valves get on, not in special circuits, but with ordinary coil and condenser types of tuned circuit. The reason for this is that it is useful to know just where ordinary methods break down, so that one does not waste time and effort on more advanced techniques where standard ones will do. Our reason for mentioning the article in the Proc. I.R.E. is that the same article gives some excellent tips on making valves "gee" at higher frequencies than they are used to.



Circuit referred to in the text. The grid-leak should be 25k. For detail on R.F.C. see text. The maximum frequency with this circuit for the 1S5 was 14 mc/sec., and for the 1S4, approximately the same frequency was reached. With the addition of filament chokes it might be possible to reach 150 mc/sec. or higher.

First of all, in the use of his special tuned circuits the author, Mr. E. Karplus, of the General Radio Company, recommends the type of circuit shown in Fig. 1. This is an ultra-audion circuit, with modifications, and if with the appropriate valves and tuned circuits it works up to 1100 mc/sec. there seems little reason why it should not be very satisfactory as a starting point for our own experiments.

In this circuit there is no feedback coil or tap to which one of the tube elements must be connected, and the degree of feedback is dependent on the particular values of grid-cathode and plate-cathode capacities found in the tube used. The grid-plate capacity does not come into the question of providing feedback, and therefore of sustaining the oscillations, because this merely becomes part of the tuned circuit. In a circuit of this kind, it can be proved that there are two simple conditions which must be fulfilled if oscillation is to take place. These conditions merely state the relationships that must exist between the various reactances connected between grid and cathode, plate and cathode, and grid and plate. Reduced to words, these state (1) that the sum of these reactances must be zero, and (2) that the reactance found between plate and cathode must be μ times the reactance between grid and cathode. Now, supposing that the grid-cathode and plate-cathode reactances are both capacitative (and they will be if no inductive elements are connected across them), this means that the grid-plate circuit must be inductive for oscillation to occur. This in turn simply means that the frequency of oscillation will be slightly higher than that to which the tuned circuit is tuned. So much for the first condition. We have now only the second one left, so if we examine it, we should get a very good clue on the operation of the circuit. Since the reactance of a condenser is inversely proportional to its capacity, condition (2) above can be re-stated: the grid-cathode capacity must be μ times the plate-cathode capacity. One would therefore expect a tube to be suited to this circuit if its grid-cathode capacity was about μ times its plate-cathode capacity. However, in practice there are

other capacities connected to the circuit that modify the relationship just stated. In particular there are unavoidable stray capacities between each end of the tuned circuit and earth, to which the cathode of the valve is connected. It has been found that because of these stray capacities, the best valves for high-frequency use in this circuit are those whose grid-cathode and plate-cathode capacities are almost equal. This does not mean that the theoretical conditions given above are not true, but only that all the possible circuit elements, both intentional and unavoidable, must be taken into account. It also gives us a valuable weapon for experimental work, such as we are describing. It is this. **If the circuit of Fig. 1 will not oscillate, it can be made to do so by adding extra capacity either across the grid-cathode path, or between plate and cathode.**

This is the reason for the second variable condenser in the circuit of Fig. 1. With the 1S4 and 1S5, it was found that when the tuned circuit was made so small that without additional capacity the circuit ceased to oscillate, oscillations were again made possible by adding extra capacity between grid and cathode. After this alteration was made, it was found that even at frequencies a good deal lower than the limit the performance of the circuit was greatly improved. That is to say, the minimum plate current was much lower, and the plate current could be increased much more by loading the oscillator than before the change was made. This means that both power output and efficiency were improved by the change.

ADJUSTMENT OF THE CIRCUIT

When the extra capacity has been added, it is found that for a given value of the tuning condenser there is an optimum setting if the grid-cathode condenser, as evinced by a lower minimum plate current. Thus, in finding the best adjustment for a given frequency, both condensers have to be varied. The grid-cathode condenser will alter the frequency, but not by so much as does the tuning condenser. Also, one setting for the former will do for quite a range of frequencies, so that there is no question of "juggling" both condensers in order to tune the oscillator to some particular frequency.

FREQUENCY MEASUREMENT

In experimental work of this kind, it is imperative to have some means of telling what frequency is being generated, and as few amateurs will have either absorption or heterodyne frequency meters at over 100 mc/sec., the only practicable method is to use Lecher wires. These are quite easy to use, and give a positive indication of sufficient accuracy for amateur purposes. For high frequency work, they should be close-spaced, say, 1 to 1½ inches, and should be about 10 to 12 feet long. If they are shorter than this they will be useless for frequencies lower than about 115 mc/sec., and it is advisable to be able to go down to 100 mc/sec. For experimental purposes, no great accuracy of measurement is needed, so that all that is required in addition to the stretched wires themselves is a steel ruler, or similar device, to act as a movable shorting bar when held in the hand, and a pair of small clips that can be slid along one of the wires. Instead of a clip, a turn of wire can be made round one of the Lecher wires, and squeezed with the pliers so that it will stay in position when set. In order to take readings with the Lecher system, a meter is needed. This can be an ordinary 0–1 ma. moving-coil meter, and should preferably be connected so as to read the grid-current of the oscillator. This gives a much more sensitive indication than a plate-current meter. To use the meter to measure grid-current, the earthed end of the grid leak resistor should be disconnected, and connected to earth through a mica condenser instead. This can have any value whose reactance is low at the operating frequency, say, 0.0005 mfd. The D.C. return for the grid is then completed by connecting the positive terminal of the meter to earth, and the negative to the now free end of the grid leak.

The Lecher line is connected to the oscillator in the following manner. The oscillator is set up near to one end of the line, and to this end are connected a pair of flexible leads, long enough to reach the oscillator. At the oscillator end of the leads, these are joined together and made into a small loop, of one or two turns only, and about the same diameter as the coil of the tuned circuit. This loop is then very loosely coupled to the oscillator tank coil. Next, the shorting bar is placed across the line at any convenient point. When the line is shorted, there may or may not be a drop in grid current shown by the meter, so the bar, still short-circuiting the line, is moved along it in either direction. If the coupling of the loop to the oscillator is tight enough, a place will be found where a pronounced dip occurs in the oscillator grid-current. If no such position is found, it is almost certainly due to insufficient coupling to the oscillator, so this is tightened, and the shorting bar is manipulated again. When the dip is found, one of the clips is moved along to mark the spot. The shorting-bar is then moved along the line in either direction from the point marked, until another spot is found where a dip occurs. This spot is marked with the other clip. The distance between the two clips is now approximately half a wavelength, at the frequency of the oscillator.

FURTHER EXPERIMENTS

When starting off with a given circuit, such as that of Fig. 1, to see how high it will go, it is best to start with a Philips type trimmer as the tuning condenser, and with a coil of reasonably large dimensions—say, five or six turns of wire wound to an outside diameter of half an inch. As long as the first experimental circuit oscillates well, which it will do as long as the initial trial frequency is not too high, there is no need to consume time in measuring the frequencies attained. The next thing to do is to take off a turn from the coil and see if the circuit still oscillates over the tuning range covered by the condensers. With valves such as the ones we are using as an illustration, the top frequency is somewhat of an unknown quantity, so as soon as the efficiency starts to drop, as shown by increased minimum plate current and decreased grid current in the unloaded state, it is advisable to take a frequency check with the Lecher lines. This can now act as the real starting point in the investigation.

Suppose now that we have found the upper frequency limit of the valve in the circuit of Fig. 1. Where do we go from here? It will be noticed first of all that Fig. 1 does not show any R.F. chokes as being used, apart from the one which allows the plate voltage to be applied to the oscillator without shunting the tuned circuit so heavily that the circuit refuses to oscillate. One reason why the circuit may have ceased to function, then, is that this choke may have ceased to present a sufficiently high impedance at the frequency where oscillation drops out. The

first thing to do is therefore to check on this point. If the frequency already attained is in the region of 100 mc/sec., and an ordinary commercial 2.5 mH. choke has been used, the logical thing is to try a simple home-made choke of the solenoid type. This can be made by winding about 100 turns of 30-gauge wire on to a 1-watt carbon resistor of some high value, say, 1 megohm. The resistor acts only as a former, and its wire ends as convenient connecting leads. When this has been made, it is wired IN SERIES with the original choke, and the circuit is tried again to see how high it will go, without altering the coil from where we left off. If the original choke was the cause of non-oscillation, we will find that the new choke allows a higher frequency than before to be reached.

Having made this modification, a new upper limit will be found, or not, according as the original plate choke was not or was functioning at the previous limit frequency.

The next most likely reason for stoppage of the circuit is connected with the valve itself. In Fig. 1, the filament has been shown as connected to earth in the usual way. This is in order as long as the frequency is not so high that trouble is caused by the inductance of the filament leads. At very high frequencies the filament lead inductance may have so much inductive reactance that although the filament is apparently earthed, in fact it is not so, and a voltage at signal frequency builds up at the actual filament inside the valve. This upsets the feedback arrangements, because the circuit works only on the assumption that the filament is at earth potential. Thus, when this trouble is encountered, the strength of oscillation gradually falls off as the tuned frequency of the tank circuit is raised, until a point is reached where there is not enough feedback to sustain oscillation. However, this does not mean that we have come to the limit of our resources. The cure is either to neutralize the inductance of the filament leads, or else to "float" the whole circuit in the air, as it were, by placing chokes in each cathode lead. This again restores conditions to where oscillation can take place, because with the whole of the filament above ground as far as signal frequency is concerned, the feedback is once more determined solely by the relations that exist between the inter-electrode capacities of the valve. The chokes should be similar to the one made as a trial for the plate choke. They will not have so much D.C. resistance that the effective filament voltage is reduced. When wiring them into the circuit, it is important to note that the one which is placed in the lead that was previously connected to earth (i.e., to chassis) should be connected **from the point on the circuit that was earthed to the chassis.** That is, the grid-leak and added grid-filament capacity should connect to the "high" end of the choke, or in other words directly to the filament pin. This now places both ends of the grid-leak at R.F. potential above earth, so that if the grid-current meter is still to be used, a further R.F. choke will have to be inserted in the negative meter lead which goes to the Fil. — end of the grid-leak. It is actually better, when the filament chokes are inserted, to dispense with measuring the grid-current, and to use the plate current as an indicator when the oscillator is being checked for frequency with the Lecher lines. This modification should allow the circuit to work at a still higher frequency than before.

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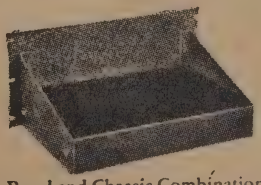

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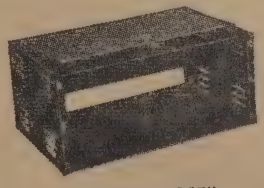

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CARE OF THE VALVE

In experimental work of this kind, it is important to see that the ratings of the valve are not exceeded, or the experiments can become quite costly. In cases where receiving valves are being used, there is generally no information on plate dissipation and maximum allowable plate voltage to assist the experimenter, but this need not cause any difficulty. In work of the kind we are describing, it is most important to remember that **the production of a good deal of power is not the object of the tests.** If after frequency tests have been completed it is desired to obtain more power output than can be given by the valve used, **then** is the time to worry about that as a separate problem, quite distinct from that of obtaining oscillations at the desired frequency. If this point is firmly held in mind, one does not fall into the trap so often found by amateur experimenters, of assuming that because the circuit will not oscillate with the recommended plate voltage, overloading the tube will make it start again. Following this fallacious line of reasoning will most often have no other effect than to ruin a perfectly good valve in very quick time!

Take, for instance, our case of the 1S4 and 1S5. The manufacturer's valve data book gives no information on these types connected as triodes, let alone as oscillators. In fact, the R.C.A. handbook RC-14, which is the small red-covered one which almost everybody possesses, does not even state a figure for maximum allowable plate dissipation. How, then, do we find out whether or not we are overloading the tube in our oscillator circuit? What IS given in the book is (a) a maximum plate voltage, 67.5v., and (b) a maximum plate current under no-signal conditions, of 9 ma. From these it is a simple matter to work out that under Class A amplifier conditions (those for normal use) the maximum allowable plate dissipation is 0.6 watts. Here, then, is a starting point. For if the valve is used as an oscillator, and the above figures are not exceeded, then the valve MUST be being operated under conditions that are not harmful. This is simply because no-signal Class A operation means that ALL the D.C. input is being dissipated as heat in the valve. Thus, when it is oscillating, and the Class A ratings are not exceeded, it must be dissipating less than the rated maximum, because some of the output of the power supply is being used in producing some R.F. energy, however small this amount may be, and only the difference between this unknown figure and the D.C. input wattage, which is known from the plate voltage and current is being dissipated by the valve.

It is a good plan in the present case to use only 45 volts of H.T. for a start. If this is done, one can possibly exceed slightly the rated maximum of 9 ma., as long as the figure of 12.5 ma. is not exceeded. Then, although the single rating of 9 ma. is exceeded, the maximum allowable plate dissipation is not.

STRIKING VOLTAGE

There is an important feature about an oscillator that is not very generally known, called its **striking voltage.** This is the plate voltage at which the circuit will commence to oscillate. If the plate voltage is lower than this figure, nothing short of raising it will induce oscillation to start. Its importance lies in the fact that it can be used as a measure of how well the circuit oscillates. The lower the plate voltage at which the circuit will still operate, the

(Concluded on page 46.)

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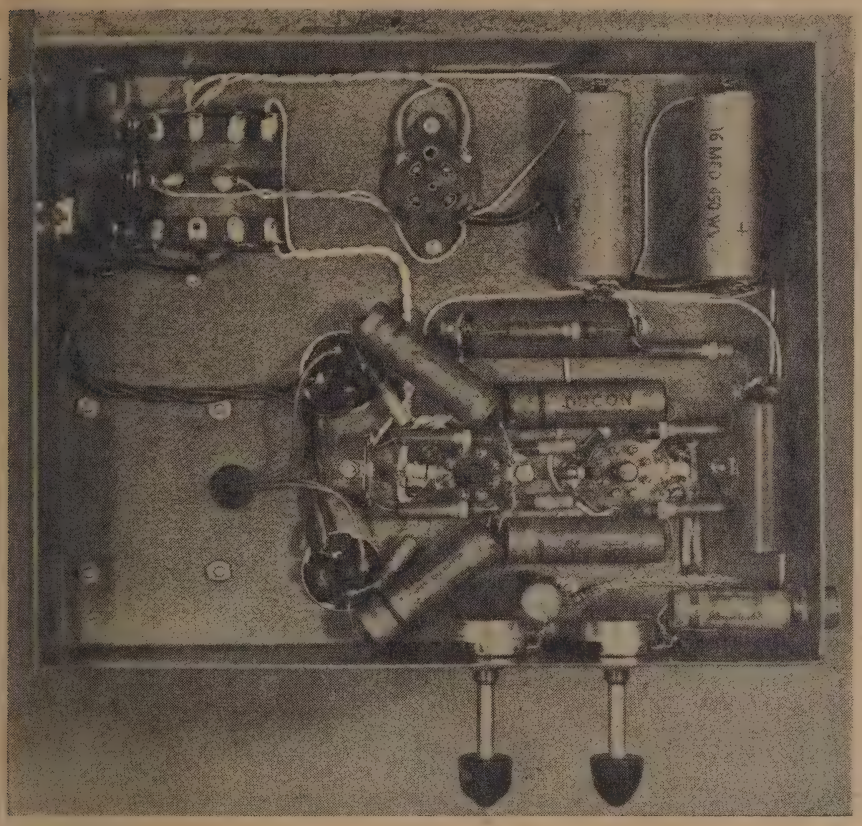
A NEW TRIODE AUDIO AMPLIFIER

This amplifier has been designed to offer special advantages in the way of a push-pull driver stage, a well-balanced phase inverter, and automatic provision of facilities for mixing two inputs. It has the usual amount of voltage gain, and with all these features employs only two valves in addition to the output tubes and power rectifier.



Under-chassis photograph of the amplifier. A top view will be found on the front cover. In this photograph the small number of parts that this amplifier takes is well demonstrated. The lay-out of the circuit can easily be followed. One of the input connectors can be seen at the right-hand bottom corner, and also the coupling condenser, whose leads are as short as they can be made. The second input is hidden by this condenser, but the shielded lead which goes to it can be seen readily. The four mounting bolts of the output transformer can be seen to the left of the 6A3 sockets.

In the design of resistance-coupled amplifier circuits, there is an almost infinite variety of arrangements which can be used, when it is remembered that there are about five phase-inverter circuits that can be used, that either triodes or pentodes can be employed in the voltage amplifier section of the circuit, and when it is possible to ring the changes on such matters as whether or not the phase inverter is to precede the power stage immediately, and therefore whether any of the voltage stages are to be connected in push-pull as well as the output stage. Almost any arrangement that can be thought of has one or more special features which make it more suitable for some purposes than for others, so that many constructors, when faced with the problem of designing an amplifier themselves, are placed in somewhat of a quandary. However, it is true in principle that an amplifier that has, say, three stages altogether, is all the better if two of them are push-pull connected, and even, for some purposes, if all of them are so arranged. With this idea in view, the present amplifier was designed, first of all, to have two push-pull stages, the second of these being the output stage. This means that one of the voltage-amplifier stages must be in push-pull.

CONSIDERATION OF AN AMPLIFIER WITH TWO PUSH-PULL STAGES

The above point having been decided, we come up against the question of what is the most satisfactory type of phase inverter to use. The three main possibilities are: (1) to use a push-pull input transformer; (2) to use one of the rather numerous varieties of so-called "paraphase" circuit; and (3) to employ the cathode-follower type, in which the plate load resistor of an otherwise normal resistance-coupled amplifier stage is split into two equal parts, one of which is placed in the plate circuit, as usual, and the other in the cathode lead.

For all but special purposes, the first method, though the simplest and capable of the highest quality if a first-class transformer is used, can be discounted at once on the score of expense. This leaves two main possibilities. These, on examination, boil down to whether or not we require the phase inverter circuit to provide useful gain, at the same time, or

whether it is to give phase inversion only, the gain being picked up by means of an additional single-ended stage preceding it.

For both these schemes there are sound arguments. For example, the single tube phase-splitter of (3) above gives very good balance between the two outputs, if properly designed, and is to a great extent unaffected by variations in characteristics of the valve for which it is designed. This is an advantage in that after a tube has been replaced no adjustments are necessary. As against this, the circuit requires that the phase-inverter shall have its cathode operating many volts positive with respect to the heater, unless one goes to the trouble of providing a separate heater winding on the power transformer specially for it. This, though a simple matter, is undesirable, as it rules out the possibility of using a standard type of power transformer, and so increases the cost of the amplifier. Again, remembering that we are considering the special case of an amplifier with a push-pull stage for the final voltage amplifier, there is the matter of hum to be considered. The cathode-follower phase-inverter, for the reason stated a moment ago, has rather more A.C. hum in its output than other circuits. This is not to say that it is therefore a bad circuit, but merely that care must be exercised in its use. One of its advantages is that it can produce an undistorted output voltage that is relatively very great. Thus, it can be made to handle signals measured in tens of volts, with the result that the small amount of heater-cathode hum which may be present is entirely swamped by the high signal level. However, it would be dangerous to assume that the circuit is sufficiently hum-free to be used at a point in the amplifier where the signal is only of the order of a fraction of a volt. This means that it is not good practice to follow this type of phase-inverter by a high-gain stage. It is safest, then, not to use it even with a medium-gain stage after it, if this can be avoided, although a low-gain stage consisting of a pair of 6J5's or 6C5's would be quite in order. In the present amplifier we are using a 6N7 as the push-pull voltage amplifier which feeds the output grids, and this has a gain of 22 to each output tube grid.

This would appear to leave as the only satisfactory circuit type one of the paraphase circuits. Of these, the self-balancing circuit usually known as the "floating paraphase" circuit is in some respects the least satisfactory since its residual unbalance is quite high. The other main circuit, which has been used several times in these pages, is the one where the input to the phase-inverter section is tapped down by making a voltage divider of the grid coupling resistor. This can give perfect balance at all but the highest audio frequencies, where the high-frequency loss due to Miller effect becomes unequal in the two halves of the stage. In order to achieve this good balance, it is preferable to incorporate a pre-set potentiometer adjustment, which will need re-setting whenever the phase-inverter valve is replaced. The circuit also gives a gain to each side of the push-pull amplifier equal to the gain of each half as a straight R–C coupled stage. In addition, the A.C. hum is no greater than that of any normal amplifier stage, so that it can be used in almost any position in the amplifier.

NEW PHASE-INVERTER CIRCUIT USED

After the above discussion, it may come as a surprise to some that this amplifier does NOT use the paraphase inverter at all! Instead we have incorporated a circuit which, though widely used in oscilloscope amplifiers, seems to have been very little thought of in connection with audio amplifiers. It combines some of the advantages of all three types of phase-inverter discussed above, and in addition, has some that are peculiar to itself.

The circuit referred to is the one recommended

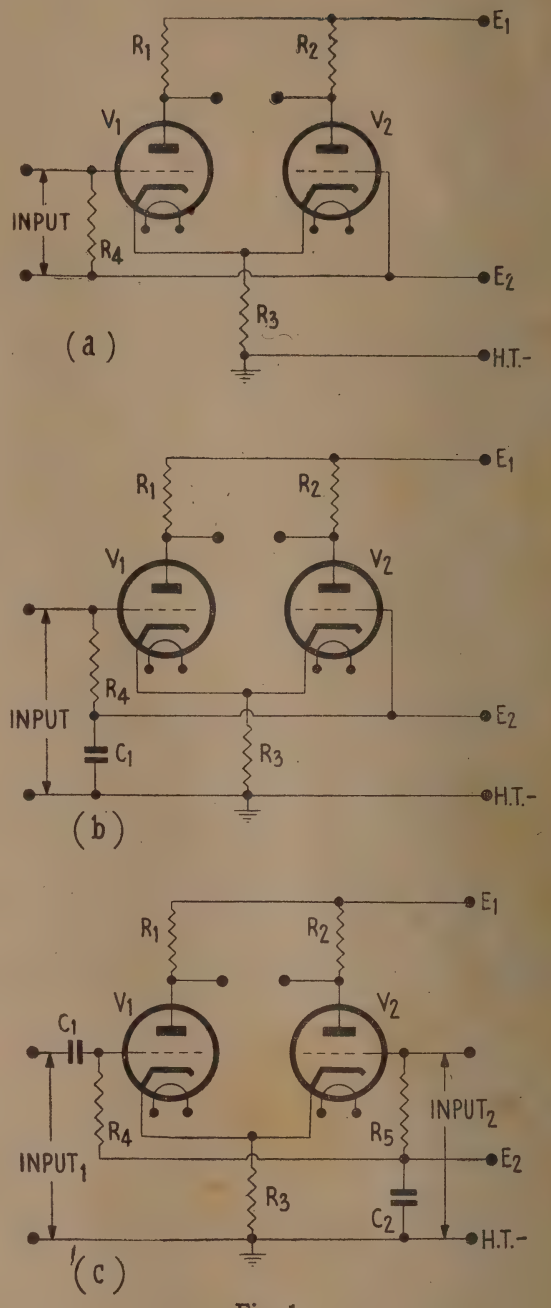
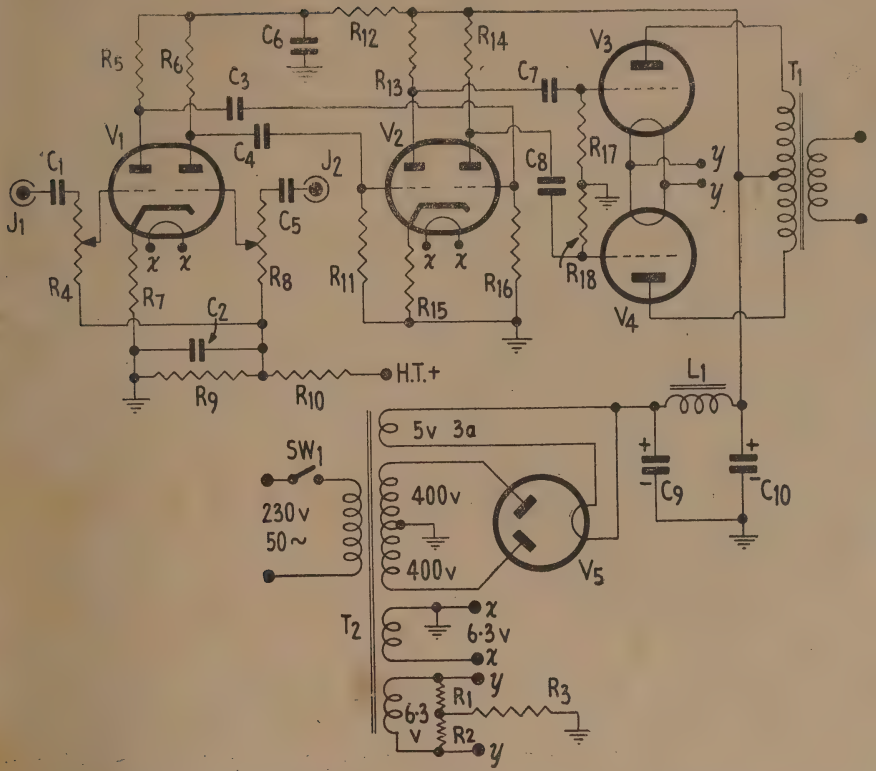


Fig. 1.



COMPONENT LIST

C_1, C_5, 0.05 mfd.
C_2, C_6, 8 mfd. 350v. electro.
C_3, C_4, C_7, C_8, 0.1 mfd.
C_9, C_{10}, 16 mfd. 450v. electro.
$R_1 + R_2$, 20 ohms, centre-tapped, wire-wound.
R_3, 750 ohms 10 watt wire-wound.
R_4, R_8, ½ meg. pot.
R_5, R_6, R_9, R_{13}, R_{14}, 100k.
R_7, R_{12}, 50k. 1 watt.
R_{10}, R_{11}, R_{16}, R_{17}, R_{18}, 250k.
R_{15}, 1500 ohms.
L_1, 20–30 H., 100 ma.
T_1, output transformer, 5000 ohms to voice-coil.
T_2, power transformer, windings as shown.
V_1, V_2, 6N7.
V_3, V_4, 6A3.
V_5, 5Z3.
SW_1, single pole on/off.
J_1, J_2, single conductor shielded input sockets.

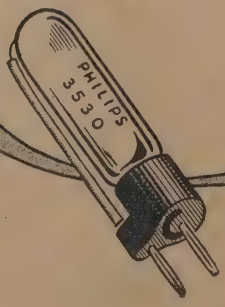
for oscilloscope use by Mr. O. S. Puckle in his well-known book on Time-Bases. A fairly complete appraisal of its advantages for this purpose will be found in "Radio and Electronics," Vol. 1, Nos. 2, 3, and 4, in an article on a Five-inch Service Oscilloscope. For audio work its features may be detailed as follows:—

(1) It has a very high undistorted output voltage, which makes it suitable for directly driving the power stage, if desired.
(2) It can be designed to have virtually perfect balance.
(3) It is not critical as to valve characteristics.
(4) It has no present adjustments to be reset after a valve change.
(5) Although it places the cathode at about 100v. positive with respect to ground, any heater-cathode hum tends to be balanced out, automatically.
(6) By a slight modification, it can be made to have two input terminals. An input voltage applied to either of these results in a balanced push-pull output. Also, the input terminals can be used simultaneously with different signals, and the circuit automatically mixes the input voltages. The outputs then each consist of the amplified sum of the input voltages, and are properly balanced with respect to each other.

These properties make it possible for the circuit not only to produce excellent phase-inversion, but to enable audio mixing to be obtained without the use of any extra valves, and without any effect on the performance of the amplifier as a whole. Since the input stage is symmetrical in all respects, the gain of the amplifier from each input to the loud-speaker is identical. Were it desired to use a low-level microphone or pick-up into one of the input terminals, it would only be necessary to add a further stage of voltage amplification, which would feed into one of the input terminals.

HOW THE PHASE-INVERTER WORKS

The manner in which this circuit functions is made clearer by reference to Fig. 1. At (a) is shown the basic circuit from which the final one is developed. R_1 and R_2 are the plate load resistors of the two triodes, and can be assumed for the moment to have a value of 100k. R_3 is an unbypassed, common cathode resistor, which also has a high value, say 50k. This resistor has flowing through it the plate currents of both valves, so that we can expect a quite large voltage drop across it. This places the cathodes at a high positive potential with respect to earth, so that if the grids were returned to earth in the usual way there would be a high negative bias on both grids. The circuit would then reach a D.C. equilibrium in which the valves were almost at cut-off. In this case only a small input voltage would be enough to cut one of them off completely, and the signal-handling capacity would be very small. For this reason, the "cold" end of the grid resistor of the input tube, and the grid of the second tube, are connected together and taken to a point of quite high positive potential. This potential we can assume to be carefully chosen in such a way that the grid bias on the valves is normal for their type. In this way, normal D.C. relationships are preserved, in spite of both cathodes and grids being at high positive potentials. Now let us consider the behaviour of the circuit to a signal fed into the grid circuit of V_1. It will be noted that



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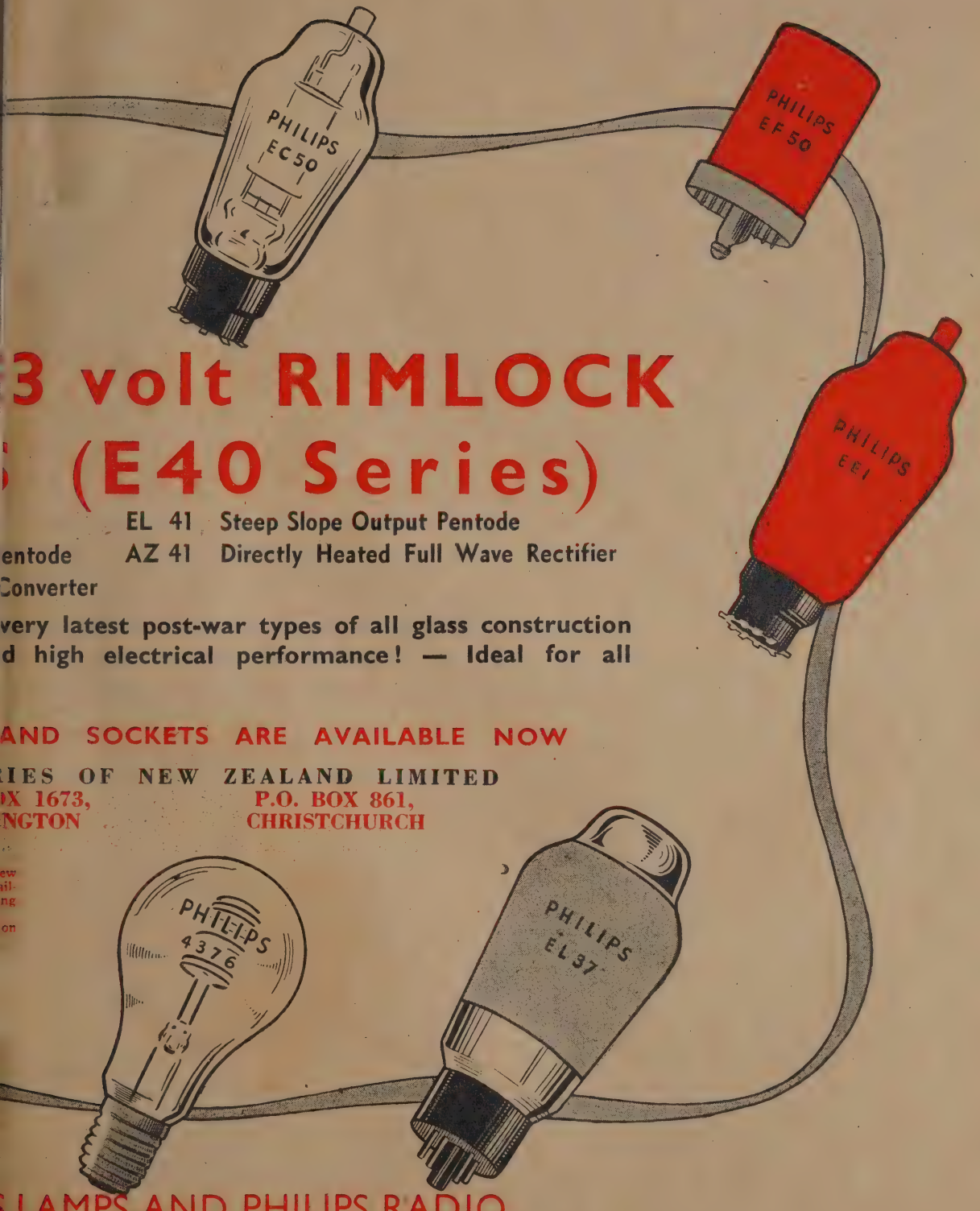

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Fig. 1 (a) shows the input as applied, not between grid and earth, but between the grid and the "cold" end of the grid resistor. In other words, it is applied across the grid resistor. In this way, the signal is fed to the grid of V_1, but no signal is applied directly to the grid of V_2. How is it, then, that V_2 receives any input signal? Considering V_1 alone, it is clear from the circuit that this valve must act, at least partially, as a cathode follower. In fact, if V_2 is imagined as being removed from the circuit, what remains is almost exactly our old friend the split-load phase-inverter itself. Now since no signal is applied to the grid of V_2, this element can for all practical purposes be regarded as being at earth potential as far as signals are concerned. But the cathode of V_2 is attached to a point on the V_1 circuit where a signal voltage appears due to the cathode-follower action of V_1. Thus, such signal as appears at the common cathode terminal is applied to the grid circuit of V_2 as surely as if it were placed directly on the grid. This signal voltage is amplified by V_2, and reversed in phase after the normal fashion. Since R_3 is also in the cathode circuit of V_2, the latter produces across it a signal voltage which is out of phase with respect to that produced in it by V_1. Now, if the voltage output (in R_3) of V_2 is less than that of V_1, the actual voltage found at the cathode terminal will be the difference between the two individual voltages. That is to say, there remains at the cathode a signal which simultaneously reduces the output of V_1 and increases that of V_2. Both these changes are in the required direction to equalise the output voltages of the two tubes, so that the circuit, by virtue of its symmetry, has a true self-balancing action.

The above qualitative description is not scientifically complete, but does serve to indicate the action that takes place. For example, it can be proved that even if the valves and plate load resistors are identical, the output will not be 100 per cent. balanced, unless the amplification in the valves is very high. In cases where low-gain tubes are used, this unbalance is apt to become serious, but this does not detract from the value of the circuit, since the unbalance can be calculated in advance, and if it is found to be too great for the purpose in hand, can be compensated by making the values of the plate load resistors unequal. In fact this process can be carried to the extent of causing the outputs to have a given ratio that is different from unity—a thing that may be useful in certain circumstances.

However, in this case the 6N7 has enough gain for the outputs to be as well balanced as is of any use, resistor tolerances being what they are. In other words, the calculation by which the differences between load resistors may be found, which gives perfect balance, gives an answer so little different from the nominal value that it is only a small fraction of the possible difference due to the use of 10 or 20 per cent. tolerance resistors.

It would be a nuisance if the input to the amplifier had to have both sides above ground, as might appear from Fig. 1 (a). However, this is easily eliminated in practice by ensuring that the point to which the grid circuits are returned is adequately bypassed to ground. This means, in effect, that the impedance (at audio frequencies) to ground of this point is so low that injecting a signal between grid and earth is virtually the same thing as connecting it directly across the grid resistor. This is illustrated in Fig. 1 (b).

The grid of V_2, as has been pointed out, resides at earth potential as far as signal is concerned. Thus, no current of any sort can flow through the wire which connects it to earth. It will therefore make no difference to the operation of the system if we insert a resistor, R_5, in the grid return. This gives us the circuit of Fig. 1 (c), which can be seen by inspection to be quite symmetrical in both grid and plate circuits. This being the case, it cannot matter whether the signal is fed into the grid of V_1 or to that of V_2. In each case the action must clearly be identical. Furthermore, as long as neither tube is overloaded, there is no reason why if two different signals are fed simultaneously to the two inputs, the presence of one should have any effect on the operation of the system with regard to the other. Thus, supposing that we put a sine-wave at, say, 400 c/sec. into the grid of V_1, the result will be equal and opposite signals at this frequency at the plates of the two valves. If, in addition, we apply a sine-wave at, say, 45 c/sec. to the grid of V_2, there will appear at the plates of both valves equal and opposite signals at this frequency also. In other words, the two input

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signals, in addition to being converted to balanced output, have been "mixed" or added together, and the composite signal will thereafter travel through the whole amplifier and be reproduced at the output.

REMAINDER OF THE CIRCUIT

We have enlarged to some degree on the circuit of V_1 in the amplifiefir circuit, because it is here that the particular interest of the present arrangement lies. The rest of the circuit is conventional, and requires little in the way of special comment. Since the plate circuits of all stages of the amplifier are in push-pull, there is practically no likelihood of trouble due to motor-boating. In fact it would probably be possible to do without decoupling altogether if this were the only point at issue. The R–C filter connected in the H.T. lead to V_1 serves the double purpose of giving extra smoothing where it is most wanted, and of dropping the supply voltage. V_1 is called upon to give only about 2v. R.M.S. signal so that a high H.T. voltage is unnecessary. The lower value enables a lower positive potential to be used at the cathode, with beneficial results as far as hum is concerned, and also keeps this voltage within the rated limits for the tube.

It will be noticed that the grid resistors of V_2, V_3, and V_4 have been kept to reasonably low values. This has been done in order to preserve the high-frequency response of the amplifier. It is not generally realised that when an amplifier consists of several stages of triodes the cumulative effect of the input capacities on the high-frequency response can be, and often is, serious. Only by keeping down the values of the grid resistors is it possible to keep the response flat to 10,000 c/sec. and higher. The values used here are adequate even where the amplifier is to use a high-fidelity output transformer.

The output stage, using the well-known 6A3's, is conventional in all respects, and requires no special mention.

CONSTRUCTION

The amplifier is built on a chassis 10½" x 8½" x 3". This gives room for the gear to be arranged as shown in this month's cover photograph, with the output transformer mounted on the chassis. There is room, too, in the front left-hand corner for an extra voltage-amplifier stage should this be needed for a low-level microphone. The two input controls can be seen mounted on the chassis front, while the input sockets are one above the other, about ¾" from the front of the left-hand side of the chassis. Since the output transformer has stout terminals for making the secondary connections, no output socket has been provided. The lay-out of the valves follows the circuit in a straightforward manner which makes for short connections and a symmetrical arrangement of the small parts. The under-chassis photograph gives a good idea of the latter. The centre-tapped resistor across the 6A3 filament winding is connected right at the power transformer, as is the 750-ohm wire-wound bias resistor. Chassis-mounting terminal lugs are used to support the 16 mfd. electrolytic smoothing condensers, which can be seen in the top right-hand corner of the picture.

The lead from the input potentiometer farthest removed from the input sockets is shielded, since it

(Concluded on page 46.)

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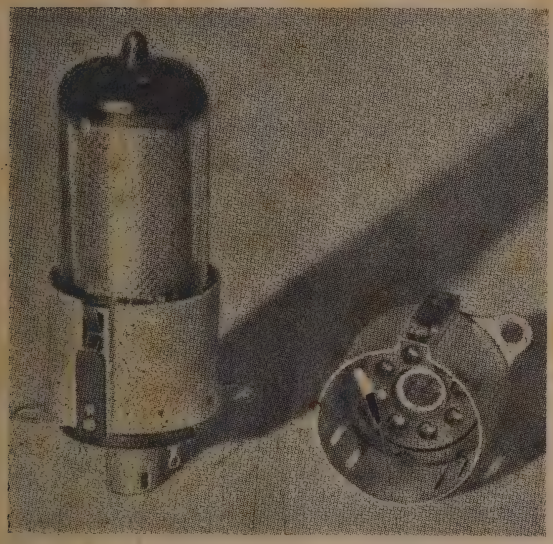
DATA

LOCK" VALVES

preceding the late war, elopments in the construc- ic metal-envelope tube and types resulted from the reduce the dimensions of to improve their perform- uencies. Each form of con- uable advantages, but each ages. An obvious line of de- fore to try and produce a valve ould combine their advantages, while their disadvantages. It has been by fo is line of research that the famous Dutch firm of Philips has arrived at a new series of tubes



which they have called the Rimlock Series. The main features of these valves can be summarized as follows:—

(1) All-glass construction, resulting in very short electrode leads, and therefore in excellent high-frequency performance.

(2) Compactness. The different types in the series are of different sizes, but on the average they are very little bigger than the standard American miniature series.

(3) Simplified construction, which results in a rigid electrode assembly, and greater reliability in operation.

(4) The precision in assembling the electrode structure is greater than with former types of construction.

(5) Low power consumption.

(6) Connecting pins are of greater diameter than those of the normal miniature valves, and are made of hard metal, which cannot become distorted in use.

(7) The location of the valves in their sockets is not dependent on the connecting pins, nor does it depend on the use of a spigot which can get broken.

(8) The valves are positively locked in place in their sockets, and equipments using the tubes can therefore be packed and transported with the valves in place, if desired, without any risk of their coming loose.

(9) They are all of the "single-ended" type, and the eight contact pins are sufficient for all types, including indirectly heated triode-hexodes.

THE ECH41 TRIODE HEXODE FREQUENCY CHANGER

This valve is the Rimlock counterpart of the ECH35, and in spite of its smaller size has a performance that compares more than favourably with the latter. For example, the ECH41 under typical operating conditions has a conversion conductance of 500 micromhos, or micro-amps/volt. The ECH35 under similar conditions of operating voltages has a conversion conductance of 650 micro-amps/volt. The difference could certainly not be noticed without the aid of instruments, and the figure is still higher than that of most other oscillator-mixer tubes, irrespective of size. The plate resistance of the ECH41 is 2 megohms, as against 1.3 megohms for the ECH35, so that some of the difference in conversion conductance is made up for in the new tube because of the smaller shunting placed on the primary of the first I.F. transformer.

The construction of the ECH41 is similar to that of the ECH35, so that the latter's advantage of low oscillator drift on short-waves is fully retained in the new tube. Similarly, the ECH41 is non-critical as to oscillator output voltage. Over a range of oscillator

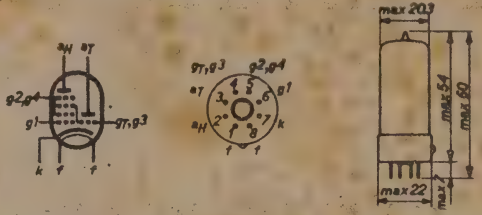
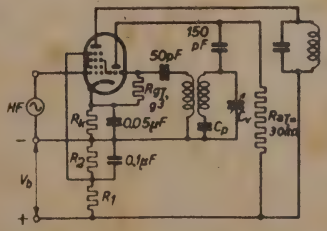


Diagram showing the dimensions (in millimetres) of the under-socket connections, and the electrode arrangement of the ECH41.

volts from 7.5 to 12.5, the conversion gain does not vary by more than 1%. In fact, the curves given later show that as long as the oscillator output is greater than about 5v. R.M.S., the conversion gain is affected only to a negligible extent by variation in oscillator



Circuit diagram referred to in the tables below. This shows a tuned-plate oscillator, but there is no reason why a tuned-grid circuit should not be used instead.

output. This makes the tube very easy to apply, and automatically takes care of quite wide variations in the oscillator coils used.

The short-wave performance of the oscillator section of the tube is excellent, as the triode has a static mutual conductance of 1.9 ma/v., which is very high for this type of valve, though not quite as high as the corresponding figure for the ECH35.

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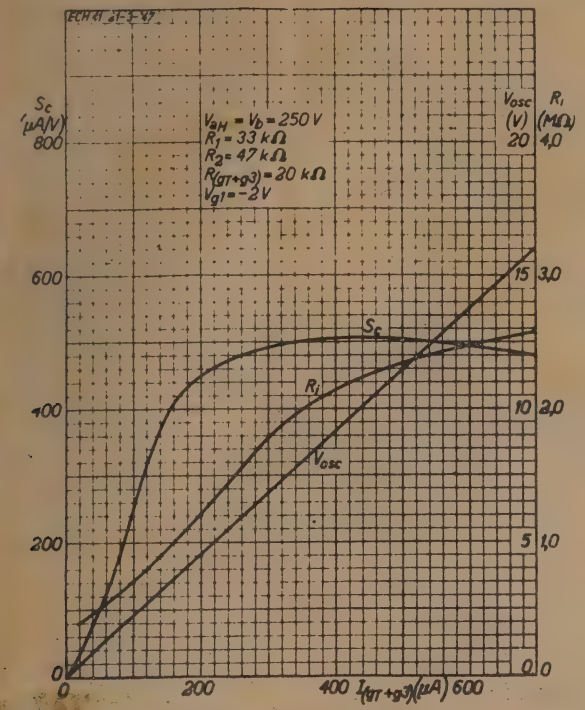


Performance curves for the ECH41. These show conversion/conductance, plate resistance, and effective oscillator voltage against oscillator grid current.

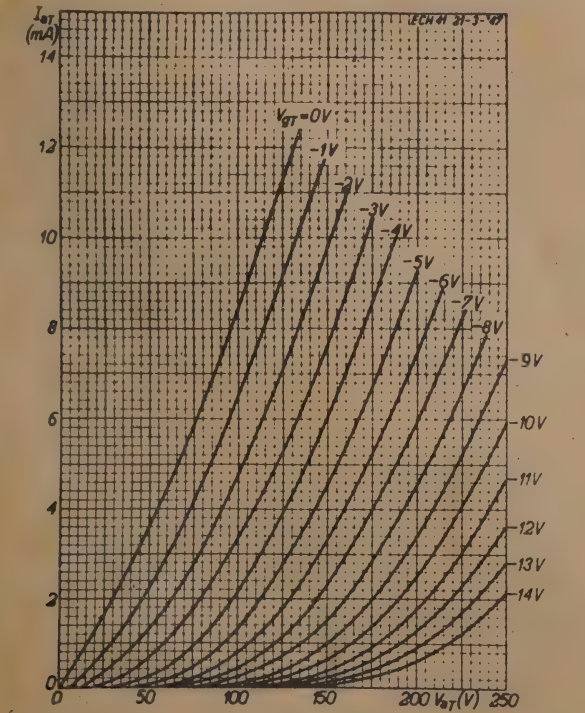
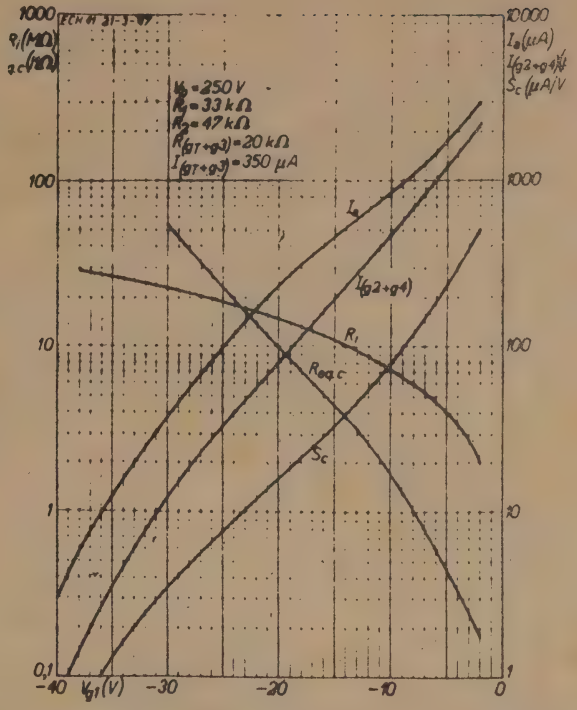


Plate-voltage–plate-current curves for the triode section of the ECH41.



Further performance curves. These show conversion conductance, S_c; Equivalent conversion noise resistance, $R_{eq\,c}$; Plate resistance, R_1; Plate current, I_a; and Screen current, $I_{(g2+g4)}$, against signal grid bias.

Tabulated data and curves for the ECH41 are given below.

OPERATING CONDITIONS FOR HEXODE SECTION

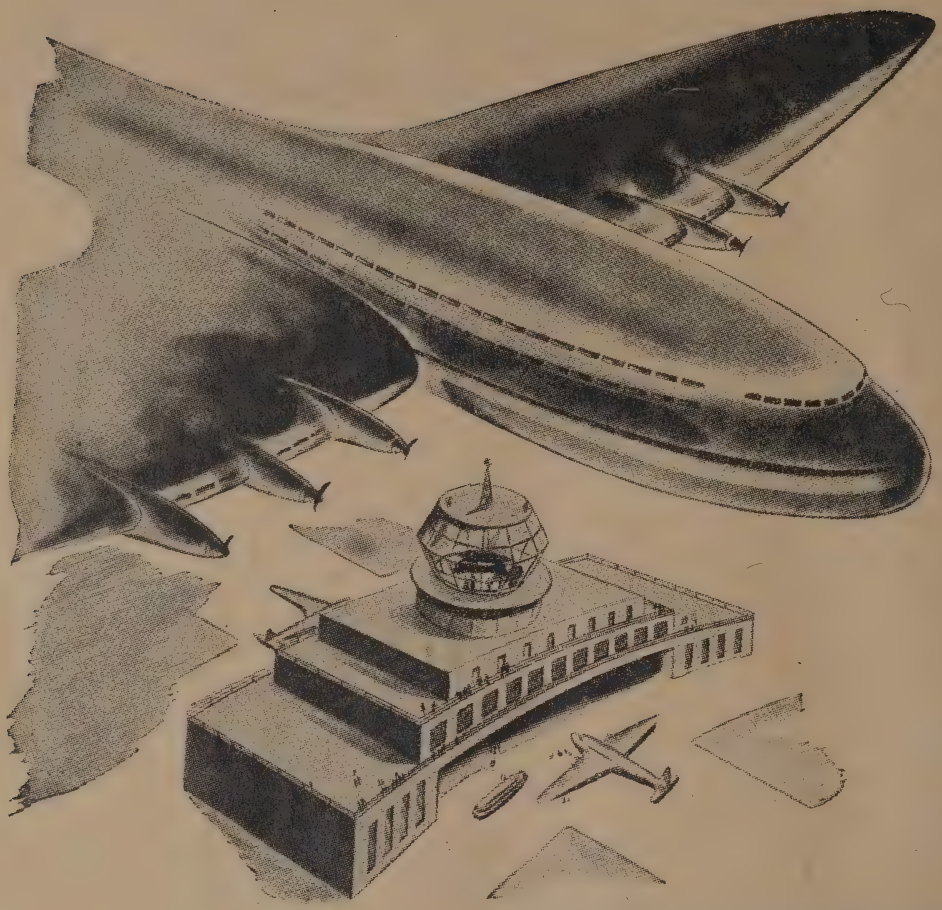
Note.—Values of resistors mentioned in the following tables refer to the circuit diagram Fig. 1. It is not essential to retain the tuned-plate type of oscillator circuit, this being the one recommended by the manufacturers.

Plate Voltage	250v.	
R_1	33k.	
R_2	47k.	
R_k	200 ohms	
R_3	20k.	
Triode Grid-current	0.35 ma.	
Minimum Grid Bias	— 2v.	—
Maximum Grid Bias	—	— 28v.
Screen Voltage	105v.	147v.
Plate Current	3 ma.	—
Screen Current	2.2 ma.	—
Conversion Conductance	500 micromhos	5
Plate Resistance	2.0 megs.	>5 megs.
Equiv. Noise Resistance	170k.	—

OPERATING CONDITIONS FOR TRIODE SECTION

Plate Supply Voltage	250v.
Plate Feed Resistor R_4	30k.
Plate Current	4.9 ma.
Grid Current	0.35 ma.

(Continued on page 47.)



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No. 8: THE EF50 AS AN OSCILLATOR

In response to numerous requests we are devoting this issue of the Experimenter to the application of the EF50 as an oscillator. High-slope valves such as this require rather special care and consideration if their performance in oscillator circuits is to fulfil all possible requirements. For instance, while there is usually no special difficulty in securing oscillation, doing so and at the same time retaining a good note under keying is a different matter. The three circuits given here are the result of a good deal of practical work, including such matters as the measurement of drift with change of H.T. voltage, and careful checking of the resultant note, so that between them they will be found to give the answer to most oscillator problems, including those of the V.F.O., the crystal oscillator for "straight-through" operation, and the crystal oscillator for harmonic operation.

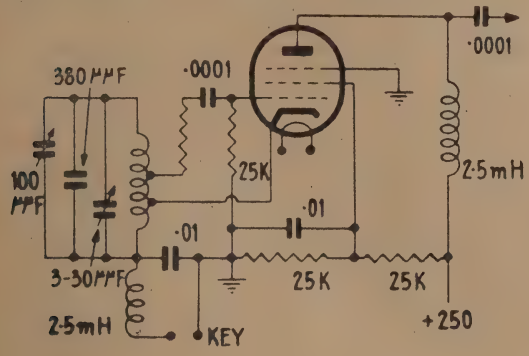

Fig. 1. Circuit for the EF50 V.F.O. The operating frequency is from 1.75 to 2.0 mc/sec.; the grid coil is wound with 20-gauge enamelled wire on a 1¼ in. former, to occupy 1¾ in. of winding space.

AS A VARIABLE FREQUENCY OSCILLATOR

Fig. 1 is the circuit recommended for using the EF50 as a V.F.O. The most noteworthy feature of this arrangement is the unusual way in which the grid and cathode are connected to the tuned circuit. It is the relation between the tapping points which determines to a large extent the performance of the oscillator with regard to frequency stability, when unavoidable changes occur in the plate and screen supply voltages. Another important matter in this connection is the ratio between the plate and screen voltages, but this, like the question of grid and cathode taps, cannot be regarded alone. With the circuit as drawn, the frequency drift with changes in H.T. supply voltage is exceedingly small, and amounts to no more than 250 c/sec. for a change of 2:1 in the latter. It is obvious from this that regulation of the power supply is quite unnecessary. The difficulty was found with the usual arrangement of connecting the grid directly to the top of the tuned circuit, that the note was rather ragged, and far from the "crystal" quality that should be expected from a good, stable V.F.O. The trouble can be attributed to the high mutual conductance of the valve, which gives it a very short grid-base, and makes it easily susceptible to over-loading. A rough note can be caused by excessive harmonic generation which in turn is caused by too much excitation. Thus, tapping the grid down the tuned circuit reduces these effects. The 2k. resistor in series with the grid feed also assists in this direction.

FREQUENCY RANGE

The coil and condensers specified give the oscillator a range of 1.75 to 2.0 mc/sec. This ensures that frequency multiplication to the 7, 14, and 28 mc/sec. amateur bands can be obtained.

OUTPUT CONNECTION

It will be noted that the output is untuned. This is because the oscillator circuit is recommended to be followed by a Class A buffer stage. This reduces the loading on the oscillator virtually to zero, and therefore prevents variation in loading, which can cause frequency-shift, even when an electron-coupled oscillator circuit is used, as here. The output of the Class A buffer should be enough to enable the plate circuit to be tuned to the second or fourth harmonic of the oscillator, and thus give enough output to drive a small pentode or beam tetrode, operating as a Class C frequency multiplier or "straight" amplifier.

It is not recommended that the oscillator be altered to run on the 3.5 to 4.0 mc/sec. band, particularly if one wishes to operate on this frequency. It is not at all certain that even if the coil proportions are preserved that the excellent frequency stability of the original will still be obtained.

KEYING

Owing to the low power of the oscillator (it draws in the region of 6 ma.) it is not necessary to have a key-click filter. With no gear of this kind, keying was very clean, and the note all that could be desired.

AS A CRYSTAL OSCILLATOR

In this role we have recommended two circuits, one specially suited for fundamental operation, and the other for harmonic use. The reason for this is that the circuit for fundamental working does not give good results when an attempt is made to multiply in the plate circuit.

The fundamental circuit is conventional, but it is

important to note that the grid-plate capacity of the tube is insufficient, even with its high mutual conductance, to give satisfactory oscillation. A 3–30 mmfd. Philips trimmer has therefore been connected between plate and grid to augment this capacity. Otherwise there is nothing unusual about the circuit. As in the V.F.O., the screen is fed from a voltage divider rather than from a dropping resistor, as this results in better stability.

With only 250v. of H.T., the oscillator has ample output to drive a pentode or beam tetrode in the next stage.

THE HARMONIC CIRCUIT

The fundamental reason why the normal crystal oscillator circuit of Fig. 2 is unsuccessful in attempt-

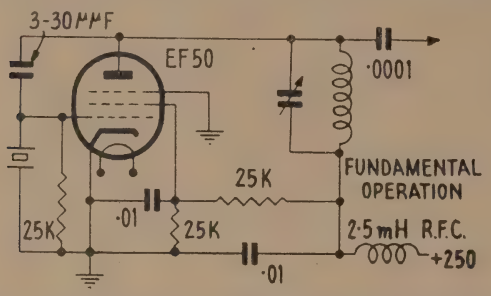

Fig. 2. Recommended crystal oscillator circuit for fundamental operation. The added grid-plate capacity can take the form of a Philips trimmer, but has been shown fixed on the diagram to emphasize that once adjusted to a suitable value, it is left fixed.

ing to work as a harmonic amplifier in the plate circuit is the same as exists for the addition of extra grid-plate capacity, namely, that there is not enough excitation. The degree of feedback to the grid circuit in such an arrangement is controlled by circuit elements which do not appear in the diagram, namely the inter-electrode capacities of the valve, and the capacities inherent in the crystal and its holder. If these capacities do not bear the appropriate relationship to each other, there is not enough feedback, and the "oscillator" circuit refuses to live up to its name. In this connection, it should be remembered that the crystal does not represent a tuned circuit directly connected to the grid of the valve, but one in which the grid is tapped down the tuned circuit, much as has been done purposely in Fig. 1, except that in the case of the crystal, the tapping down comes about through the voltage-dividing action of the holder capacity, and that of the crystal, regarded as a tuned circuit. Thus, the feedback in the conventional pentode crystal oscillator circuit of Fig. 2 has to be increased, as outlined above, by adding external capacity to the grid-plate capacity of the tube. Now, to achieve satisfactory operation on the crystal frequency, approximately 10 mmfd. of the Philips trimmer has to be used. This means that for harmonic operation there is still insufficient feedback. In other words, the circuit does not oscillate strongly enough to give the large harmonic output that is needed if output is to be taken by tuning the plate circuit to the frequency of the desired harmonic.

For this reason, the circuit of Fig. 3 was used for the purpose outlined above. If the suppressor and screen are ignored, the circuit boils down to that of a Pierce oscillator, with the control-grid and screen of the EF50 acting as grid and plate, respectively, of the triode. This arrangement is satisfactory because it enables much stronger coupling to be obtained to the crystal, and therefore much stronger oscillation. In this case the screen is fed from a dropping resistor, because a requirement of the circuit is that the screen should be at signal voltage with respect to earth.

The circuit is capable of producing useful output on any harmonic of the crystal up to and including the fourth, so that excellent operation will be obtained on 20m. using an 80m. crystal, and on 10m. with a 40m. one.

There is a point worth noting with regard to the note from the circuit of Fig. 3. If this is checked with a heterodyne wave-meter, it will be found that as the latter is tuned through the signal, a peculiar modulation effect becomes apparent. It might therefore be supposed that the note from the oscillator is very poor, but such is not the case. The effect referred to occurs only where the wave-meter fundamental is on the same or a lower band than the crystal, and where the output of the oscillator is being monitored directly. What happens is that two beats are heard simultaneously in the output of the monitor, one between the fundamental of the monitor and the fundamental of the oscillator, and the other between the harmonics of each, at the desired output frequency. The apparent modulation effect then arises because of the difference in frequency between the audio notes produced by the two beats referred to. For example, if the operating frequency is the

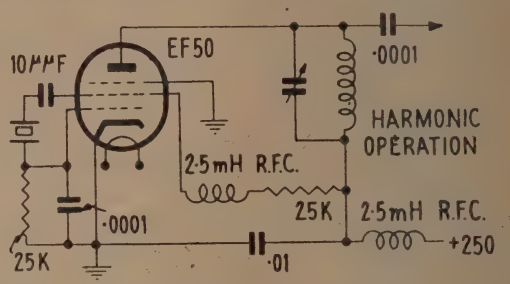

Fig. 3. Recommended circuit for crystal oscillator with harmonic operation.

second harmonic of the crystal, and the beat note between the fundamentals is, say, 100 c/sec., the beat between the second harmonics will be 200 c/sec., and the two will be heard simultaneously. In fact, when the first beat is heard, it will be that between the fundamentals, because this one must always be half the frequency of the other. Moreover, since the fundamental beat will be as loud, if not louder, than the harmonic one, the observer will tend to regard the fundamental beat as the true one, and the harmonic one as a spurious signal. As long as this fact is recognised, there will be no unjust criticism of the circuit! It should be mentioned that if the output of the whole transmitter, rather than that of the oscillator, is monitored, the above ambiguity cannot occur, because the fundamental beat will be so much weaker than the desired one. When the phenomenon is observed, it will be particularly noticeable that the character of the note changes as the monitor is tuned through the signal. This is understandable, since the relative phase of the two audio notes concerned is always changing as the monitor is tuned.

(Continued on page 45.)

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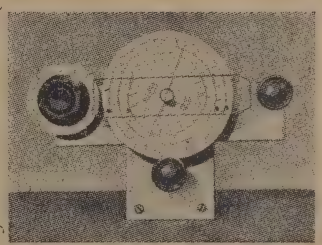

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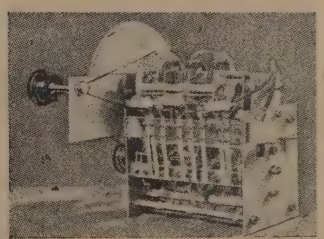

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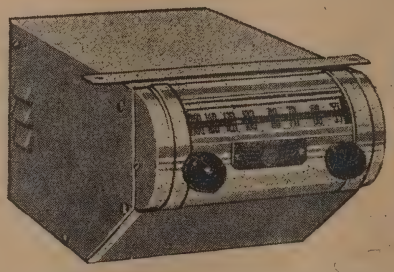

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118 VICTORIA STREET, AUCKLAND

A Practical Beginners' Course

Part 21

BANDSPREAD AND BANDSPREADING

Last month's instalment concluded with a description of the difficulty encountered in tuning a shortwave set which uses the same sized tuning condenser as is employed to cover the broadcast band. The band of frequencies occupied by a transmitting station depends on the highest audio frequency that is to be transmitted. For example, 3YA's frequency is listed as 720 kc/sec. This means that 720 kc/sec. is the frequency of its carrier, and when there is no modulation on it, this is the only frequency being transmitted. Now, the mathematicians can prove (and the same result can be arrived at experimentally) that if this carrier is being modulated by an audio note of 10 kc/sec., the transmission now consists of some carrier frequency (720 kc/sec.) and two **side-frequencies,** whose values are 710 and 730 kc/sec. Now, in actual practice, 3YA transmits as high an audio frequency as this only very occasionally during a musical programme, but the audio currents representing music are very complex, and may at any moment consist of a large number of frequencies ranging from, say, 20 c/sec. to 10 kc/sec. In this case there is a large number of side frequencies being transmitted simultaneously, but if 10 kc/sec. is the highest audio frequency that is produced by the studio equipment, all of the side-frequencies will lie between the limits 710 to 730 kc/sec. Thus 3YA needs a band of frequencies 20 kc/sec. wide, and centred on the carrier frequency of 720 kc/sec., if the station is to transmit music with this degree of fidelity. Not all transmitters take up as much space as 20 kc/sec., because they do not all attempt to transmit audio frequencies as high as 10 kc/sec., but this figure will serve as an illustration of the principle about which we are talking.

The whole of the broadcast band covers, roughly, 540 to 1600 kc/sec., which is a band 1060 kc/sec. wide. Now, if each station requires a 20 kc/sec. band for itself, in the way we have illustrated, the broadcast band can accommodate only 53 stations side by side. If they were all placed closer than this, some of the side-frequencies of one would be heard when a set is tuned to the station next to it, which would constitute interference.

Now, if we have a shortwave receiver, using the same tuning condenser as is required to cover the broadcast band, this receiver will cover a band in which the ratio between the highest and lowest frequencies is the same as for the broadcast band. For the latter this ratio is almost exactly 3:1, since $3 \times 540 = 1620$. Thus, if our shortwave set is tuned to 7 mc/sec. at the low-frequency end (i.e., with the condenser plates fully meshed), the highest frequency on the dial would be approximately 21 mc/sec. Thus, the band covered by the set would be $21 - 7 = 14$ mc/sec. wide, which is the same thing as 14,000 kc/sec. wide. Thus, if each station occupies 20 kc/sec. as before, there is room on this band of frequencies for 700 stations side by side!

Now think what this means in terms of tuning a set. The usual tuning condenser turns through an angle of 180 degrees. On the broadcast band, which accommodates 53 stations, this means that each one occupies $180 \div 53 = 3.2$ degrees rotation of the condenser shaft. But if the set covered the other band of, say, 7 to 21 mc/sec., where there could be 700 stations, each one would occupy only $180 \div 700 = 0.24$ degrees. This is a very small angle indeed, and with an ordinary plain knob on the condenser shaft requires very ticklish adjustment indeed if the set is to be properly tuned to a station. That is why, any set which uses the same tuning condenser on shortwaves as it does on broadcast, is so much more difficult to tune on the former.

This brings up the question of whether anything can be done which will make shortwave tuning easier. What is wanted is some scheme which will spread only a few of the 700 shortwave stations over 180deg. rotation of the tuning knob. Even on the broadcast band, tuning is a bit too difficult if an ordinary small knob, about 1 in. in diameter is attached directly to the condenser shaft, and it is preferable to do

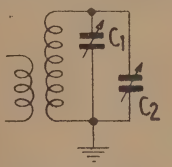


Fig. 30 (a).

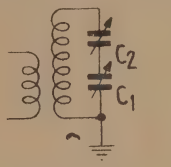


Fig. 30 (b).

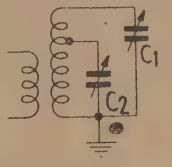


Fig. 30 (c).

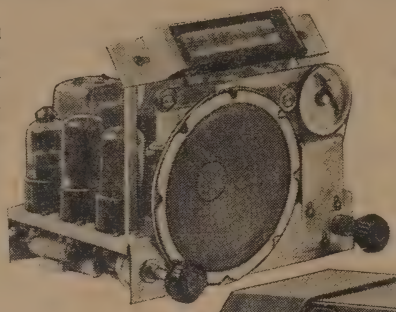
something about the broadcast band, too, if possible. The problem of spreading only a few stations to occupy 180deg. rotation of the tuning knob is known as **band-spreading,** or the provision of **band-spread,** and its name is by now almost self-explanatory.

The easiest way of providing band-spread is to use a simple system of gearing between the tuning knob and the condenser shaft. That is, the latter is geared down so that several rotations of the knob are required to make the condenser rotate through its 180deg. In broadcast sets the gearing ratio is usually about 6:1, so that three full rotations of the knob turn the condenser through its 180deg., or half-turn. This gives almost about 20deg. of knob rotation for each station on the dial. Now, if we are on the 7–21 mc/sec. shortwave band, as used in our previous illustration, we would need to have our condenser shaft geared down to the extent of about 84:1 in order that each station should occupy about 20deg. of knob rotation.

This system of band-spreading, though workable, has several disadvantages. In the first place, it is quite a difficult and costly business to make a gear train or similar mechanism that will give as much reduction as this without any backlash, which, if present, renders the whole thing useless. Secondly, if as much band-spread as this is obtained in this way, we would have to rotate the knob 42 times in order to tune from one end of the band to the other, which is very inconvenient under certain circumstances. To meet this difficulty, some mechanical systems have been made which give the choice of two gear ratios, say, 6:1 for broadcast tuning and for covering the dial quickly, and a much higher ratio which can be engaged by pulling or pushing the tuning knob, and which is used for accurate tuning on the shortwave bands.

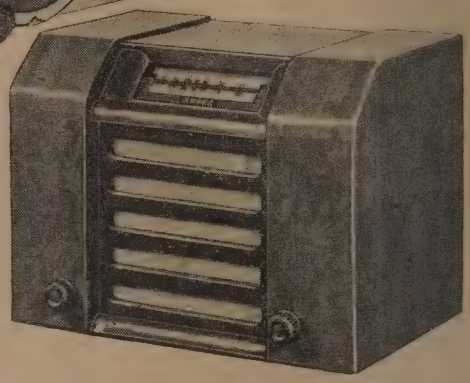
SMALL BEDSIDE RADIO—An easily built KIT-SET

THE CIRCUIT employs 5 tubes in a well-tried line up, starting with a 6K8 mixer, 6K7 I.F. amplifier coupled with high efficiency iron-cored I.F. transformers, 6Q7 second detector and audio, and 6V6 output tube for clear tone and plenty of power. The 6X5 rectifier provides high tension with minimum of heating. The use of a P.M. speaker eliminates one of the most common faults of small radios, i.e., distortion of the speaker cone through heating due to lack of ventilation around the speaker field. The separate filter choke used for smoothing in place of the field coil has much lower resistance, so gives less voltage drop in the high tension supply and less heating.



THE KIT SET is not just an assembly of standard parts which can be fitted together. It is a complete and properly designed radio receiver in un-assembled form and if neatly and carefully made up is comparable in appearance and performance with any first class factory-made set.

CHASSIS AND LAY-OUT: Extremely compact size without undue cramping of components is achieved by the unique arrangement of the parts. As may be seen in the illustration, the tuning condenser is mounted in what is normally waste space above the power transformer. It is supported there by the dial frame and a bracket which also conveniently holds the aerial coil. All parts are punched ready for easy assembly, slots being provided in such a manner as to allow accurate alignment of the dial frame in relation to the chassis and cabinet. The whole assembly is cadmium plated for neat appearance and easy soldering to earth lugs which are provided just where required.



THE CABINET is in highly polished walnut veneer and measures 10" x 7½" x 6¼". Built in escutcheon and sloping etched glass slide rule dial.

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202 Thorndon Quay, Wellington

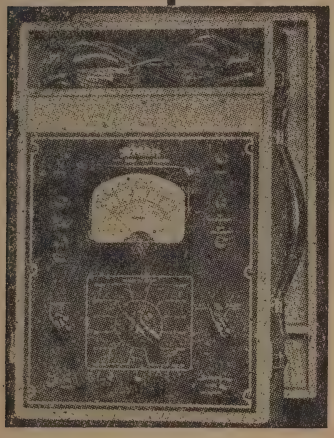
However, such mechanical band-spread systems are confined for practical purposes to commercially manufactured sets, and are therefore of not much practical interest to the experimenter. Fortunately, however, there are easily applied electrical methods of obtaining band-spread which will be discussed in a succeeding instalment.

Just as it is possible to achieve bandspread by purely mechanical means, so it is possible to use a completely electrical method of bandspreading. There are a number of ways of doing this.

ELECTRICAL BANDSPREAD

One way of making the whole dial cover only a small range of short-wave frequencies is very simple, and consists in using a very small tuning condenser. Thus, suppose we have a coil which needs, say, 110 mmfd. of condenser capacity in parallel with it in order to tune in the low-frequency end of the 80m. amateur band, which covers from 3.5 to 4 mc/sec. If, instead of using a variable condenser with a capacity range of about 10 to 110 mmfd., we make 75 mmfd. of the required capacity fixed (by connecting a 75 mmfd. fixed condenser across the coil) and then make up the total capacity with a variable condenser of 35 mmfd. maximum capacity, we will be able to tune to 3.5 mc/sec., with the variable condenser all in, since the total capacity in circuit is $75 + 35 = 110$ mmfd. But the variable condenser will have a maximum capacity of, say, 5 mmfd., so that its variation is $35 - 5 = 30$ mmfd., and the total capacity variation in the circuit is from 110 to 80 mmfd. Thus, when the variable condenser is fully open, we still have 80 mmfd. across the coil, whereas if the whole of the capacity had been provided by a variable condenser of 110 mmfd. maximum capacity, we would have only about 10 mmfd. left across the coil when the condenser was fully open. In the two cases, the lowest frequency that can be tuned is the same, but where we have used the small variable condenser, the highest frequency is much lower than that obtained when the large variable is used. In the first case, the highest frequency would be 4.09 mc/sec., so that the whole dial would take in only the amateur band from 3.5–4.0 mc/sec. With the larger condenser the highest frequency reached would be 11.6 mc/sec. Again, using our earlier illustration, which assumed that we could have a station every 20 kc/sec. across the dial, the small condenser would give us 7° rotation for each station. This would be about twice the spread that is obtained on the broadcast band. However, with the large condenser, we would have only 0.45° rotation for each station—only 1/15 as good as before. Now this scheme of making the variable condenser very small can be carried to whatever length we please, simply by making the capacity variation smaller.

For Absolute Accuracy



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Five D.C. voltage ranges at 20,000 ohms per volt: 2.5, 10, 50, 250, 1,000.
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Five output meter ranges: 2.5, 10, 50, 250, 1,000 A.C. volts.
Five DB. ranges: −18 to +3, −6 to +15, +8 to +29, +22 to +43, +34 to +55.
Four ohm-meter ranges: 4,000; 40,000; 400,000 ohms 40 meg-ohms.
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A little thought, however, will show that the scheme outlined above has one very serious drawback, at least. It is this: we usually want our short-wave set to cover a wide range of frequencies, say, from 3 td 30 mc/sec., and if we used only a small variable condenser, we would need a very large number of coils, since each one would give us such a small tuning range. However, there is a very simple way out of this difficulty, and this is illustrated in Fig. 30 (a). Here we have **two** variable condensers in parallel. One of them is large, say, 100 mmfd. maximum capacity, while the other is small, say, 30 mmfd. maximum. The large one is called the **band setting** condenser, and the small one the **band spread** condenser. As far as bandspread is concerned, the system is exactly as the one we have already described, for in use, the large condenser is set so that the correct minimum frequency is reached, and thereafter all tuning is done with the bandspread condenser. The band setting condenser merely replaces the fixed condenser in our illustration. Since the band setting condenser can be varied, too, each coil can cover a wide range of frequencies. With the coil used to illustrate the principle, and with a band setting variable condenser of 75 mmfd. instead of a fixed one of this value, the whole range of 3.5 to 11.6 mc/sec. would be covered, and yet by leaving the large condenser set, we can get good bandspread at any point on this range, tuning with the bandspread condenser.

The scheme just described, and illustrated in Fig. 30 (a), is called **parallel bandspread,** because the band setting and bandspread condensers are connected in parallel.

OTHER METHODS

We have described the parallel system in some detail in order to show how electrical bandspread systems in general operate. There are two other main methods of achieving the same result, but their principle is exactly similar to the first one—namely, that the tuning range is restricted so that the full 180° rotation of some condenser in the circuit gives only a small change in the frequency of the circuit.

The scheme illustrated in Fig. 30 (b) is known as **series bandspread,** because here the band setting and bandspread condensers are connected in series. The third system is known as **tapped-coil bandspread,** because the bandspread condenser is connected across a part only of the coil, instead of across the whole of it, as is usually the case. The two latter methods have advantages for special purposes, but for general experimental work the parallel scheme is the most easily applied and handled. **It has the advantage that it can always be applied to any circuit, whatever coils and condensers may have been specified, simply by connecting the small bandspread condenser in parallel with the tuned circuit.**

(To be continued.)

BEACON TECHNICAL TOPICS

High Quality Audio Transformers

Recent articles in *Wireless World* and *Radiotronics* No. 128 have served to call attention to the inherent distortion introduced by audio transformers of all types. Over a decade ago this matter was fully discussed in the technical press but even to-day there are those who weigh up the merit of a transformer solely by its frequency response, without regard to the amount of distortion it produces.

Judging by the many orders Beacon have executed for low-distortion output transformers for Williamson's 15-watt KT66 amplifier (since adapted by A.W.A. to use triode connected 807's), the majority of high fidelity enthusiasts are paying considerable attention to the measured characteristics of this important component.

While some manufacturers adjust the primary and leakage inductances to values that enable them to claim 'flat from 20 cycles to 20 kilocycles," this is not sufficient. In the majority of cases such an output transformer would not handle full power at either end of the frequency range without considerable distortion. It is necessary, therefore, that the primary inductance be much larger, and the leakage inductance much smaller, than is required for wide range uniform response, to achieve low distortion. This is the basis on which Beacon designs its better class transformers.

Transformers of this type are designed for a specific purpose and are not intended as a universal output to match any tubes to any load from 1 to 500 ohms. Unless definitely stated otherwise, transformers of this latter variety usually have a high insertion loss, together with a frequency response that changes with the tappings used.

For most purposes a single ratio transformer is satisfactory, as nearly all large P.M. speakers have a voice coil impedance of 15 ohms. It is practical, however, to tap this winding to suit 8 or 10-ohm speakers if required.

(This subject will be continued in the next issue.)

IAN C. HANSEN.

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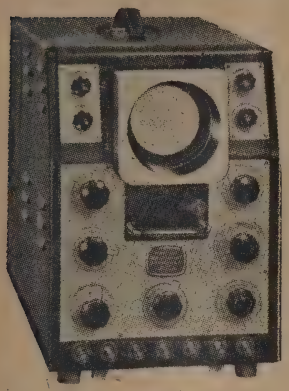

The Model 1035 is a general purpose Oscillograph, consisting of a Double Beam Tube Unit, Time Base, Y Deflection Amplifiers and internal power supplies.

The traces are presented on a flat screen Double Beam Tube operating at 2 kv. and signals are normally fed via the amplifiers, with provision for input voltage calibration.

The Time Base is designed for repetitive, triggered or single stroke operation and time measurement is provided by a directly calibrated Shift Control.

Power Rating

Mains Voltage—105 to 115, 120 to 130, 200 to 215, 216 to 234, 235 to 255.
Mains Frequency—50 to 100 cycles.
Power Consumption—170 watts (approx.).
Tube H.T. supply 2000 volts, Amplifiers 450 volts, Time Base 370 volts.

Dimensions

Height, 16½ ins. including feet.
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Cathode Ray Tubes

Y sensitivity direct to tube 675/V ± 8% 3.0 volts per mm. D.C.
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Output of both Amplifiers, Time Base and direct connections to tube plates and modulator circuits are available at the side of the instrument.

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150 milliseconds	1500 microseconds
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Time Base volts available at high impedance at X1 terminal. Switch positions provided for EXT. T.B. and Time Base "OFF." Flyback suppressed.

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Y1 Amplifier 3 valves.

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15 volts	10	3.0 Mcs.	4.5 Mcs.
5 volts	30	2.2 Mcs.	2.8 Mcs.
1500 millivolts	100	1.6 Mcs.	2.0 Mcs.
500 do.	300	1.0 Mcs.	1.4 Mcs.
150 do.	1000	250 Kcs.	500 Kcs.
50 do.	3000	60 Kcs.	250 Kcs.

L.F. Response down to 20 c.p.s.
Maximum Input Volts, 500 D.C.
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Single valve.
Directly calibrated voltage scale with 5 ranges. (Accuracy ± 10%)
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Input impedance, 0.2 megohms.
Input capacity, 35 pF.

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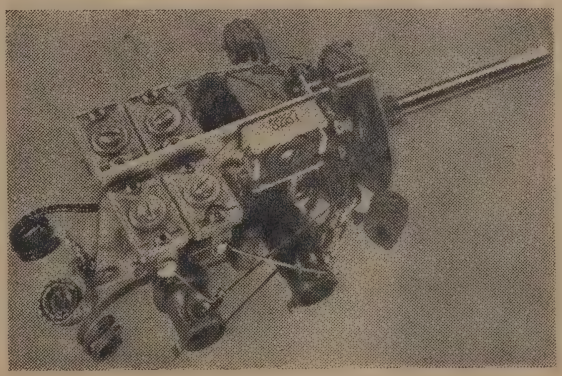
A NEW COIL ASSEMBLY



Inductance Specialists' New Type 24 Dual Wave Coil Assembly is designed to provide a highly efficient, compact, completely wired and factory tested and aligned coil assembly for use in receivers employing a single selector stage before conversion. The assembly incorporates the new **Cylinder Iron Dust Core Broadcast Aerial Coil,** mounted under a 2½ in. chassis and is secured by means of a single mounting hole and locking pin. Typical overall sensitivity measurements on the broadcast band give a reading of less than 4 microvolts for S:N ratio of 15 db.

Two types of assemblies are available:—

Type 24AX—for use with 6K8 converter tubes and types.

Type 24AW—for use with the English octal converter type and the new type Rimlock series.

Frequency Coverage:

Broadcast—540 k/c. to 1,600 k/c. } Tuning Conden-
Short-wave—6 m/c. to 20 m/c. } ser 420/13 mmfd.
Intermediate Frequency—465 k/c.

Associated Components designed, recommended, and stocked by Inductance Specialists, for use with the Assembly:—

Tuning condenser—Plessey, Type "K" two-gang.
Dial and Scale—Type D/2, SC/1. Spin tuner, slide-rule type with two-colour glass edge-lit scale (scale extends full length of chassis).
Intermediate transformers—Type 142, 465 k/c. iron core.
Chassis—11 in. x 7 in. x 2½ in. Type 17, stamped for octal sockets; Type 27, stamped for the new English Rimlock sockets.

Note: The chassis Types 17 and 27 are also suitable for standard broadcast use. Mounting holes are arranged for the components mentioned above and in addition the following particulars are given:—

Rimlock valve socket holes (Type 27 chassis) for standard Rimlock socket.
Octal socket holes (Type 17 chassis) for Amphenol clip type or standard wafer type. Securing holes 1½ in. between centres.
Power transformer holes for "Beacon" flat type 60 ma. rating or similar type transformer.
Electrolytics—¾ in. dia. hole for screw type mounting, plus mounting holes for clip type 1⅜ in. between centres.
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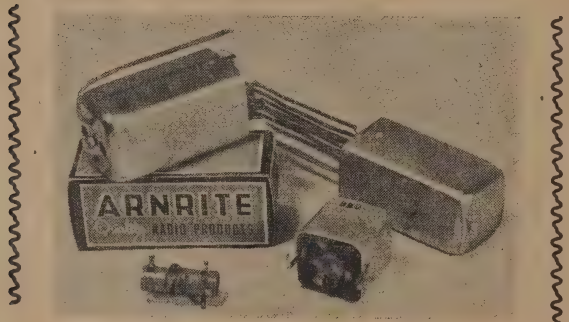

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ANNUAL GENERAL MEETING OF THE N.Z. RADIO TRADERS' FEDERATION

The Annual General Meeting of the New Zealand Radio Traders' Federation held in Wellington was attended by Messrs. G. J. Markby (President), W. I. Cunninghame, D. B. Billing, J. Hallett, I. R. Cosgrove, R. R. Hayman (Wellington); S. D. Mandeno, H. J. Barr (Auckland); F. Emmett (Wanganui); S. O. Dillon (Canterbury); J. Fairclough (Napier and districts); Keith W. Walker (Nelson); E. B. Borham (Manawatu); A. J. Howorth (Dunedin); and D. R. Cattell (Assistant Secretary).

Prior to the opening of the meeting, the Chairman referred to the passing of two very fine members of the radio world, namely, Messrs. H. W. Clarke and A. H. Mackrell. As a mark of respect, members stood in silence for a few minutes, after which the Secretary was requested to convey the sympathy of the Federation to Messrs. H. W. Clarke Ltd. and Messrs. Dickey's Ltd.

Many matters affecting the radio traders were discussed and Price Tribunal matters received considerable attention.

A letter was received from the Price Tribunal pointing out that some members of the Federation were selling radio component parts without prior approval of prices, drawing members' attention to the Prohibition of Sales Notice 1946 No. 1 appearing in the Gazette on the 22nd August, 1946, and requesting that the Federation Office advise the Price Tribunal when all members had been notified of their obligation to the Tribunal.

The Secretary advised that he had written to the Tribunal stating that this letter had been circulated to local associations for their information.

After discussion a committee consisting of Messrs. W. I. Cunninghame and D. B. Billing with power to add was set up to deal with all Price Tribunal matters. Members will be aware that the Federation sub-committee has in the past proved most valuable in dealing with the Price Tribunal.

Messrs. Cunninghame, Walker and Billing drew attention to membership, stating that only a small percentage of licensed radio dealers in New Zealand belong to the Federation. It was considered that membership could and should be considerably larger, thus providing not only additional finance, but also adding greater weight to Federation pronouncements.

Following a discussion on Radio Dealers' Licence Fees and correspondence, the election of officers took place resulting as follows:—President, Mr. G. J. Markby; Vice-President, Mr. J. Fairclough; Immediate Past President, Mr. W. I. Cunninghame; Executive, Messrs. E. B. Boreham (representing North Island Minor Associations), K. W. Walker (representing South Island Minor Associations), and four members to be nominated by the Auckland, Wellington, Canterbury, and Otago Radio Associations, respectively; Auditor, Messrs. G. Y. Berry & Miller, at the same remuneration as heretofore; Secretary-Treasurer, Mr. C. G. Camp.

Messrs. Markby, Billing, and Cunninghame then spoke of the good work done throughout the year by Mr. Camp, Secretary, and Mr. Cattell, Assistant Secretary.

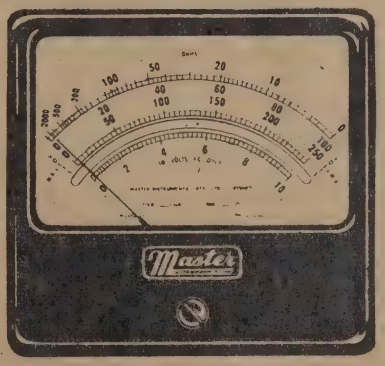
Mr. Mandeno moved:—

"That a letter be sent to the Broadcasting Board suggesting the establishment of a short-wave

(Continued on page 48.)

Master

PRECISION ELECTRICAL METERS



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THE EDITOR'S OPINION

THE "INDUCTANCE SPECIALISTS" RANGE OF AERIAL AND R.F. COILS FOR THE BROADCAST BAND

The firm of Inductance Specialists has recently added to its range of coils for uses on the broadcast band by bringing out new types in both the shielded and unshielded varieties. Both of these new types employ cylindrical iron-dust cores, and are provided with top-capacity coupling in the case of the aerial and R.F. coils, in order to equalize the gain of the completed receiver over the whole band. We intend to say a little more about this later, but first of all it will be of assistance to readers if we describe the complete range of R.F. and aerial coils. In this way it will be made clear how the new series of coils fit into the complete range.

R.F. Coupling Coils

Left: Type 95A

Above: Type 35A

UNSHIELDED TYPES

There are now two types of unshielded aerial and R.F. coupling coils available, namely, aerial coils types 50 and 30, and R.F. coils types 55 and 35. These are specified by the manufacturer as follows:—

Aerial Coils

(1) **Type 50:** This is the older type of unshielded aerial coil. It has a high-impedance primary winding, and is wound with Litz wire on a ½" bakelized paper former 1½" long. Connections are to four soldering lugs riveted into the former, two at each end. Both primary and secondary are universal-wound in order to achieve low self-capacity, and, by making the high-potential end of the coil the inside of the winding, to restrict the external field as far as possible. This, and its companion R.F. coil type 55, do not employ built-in top-capacity coupling, so that manufacturers or constructors can add their own externally if this is desired.

(2) **Type 30:** This is the new aerial coil. Its construction is similar to that of the type 50 aerial coil, except that this one uses an iron-dust core, giving it increased gain, and also has top-capacity built into its construction, so that without added coupling, the gain is more constant over the band than can be realized with the type 50 coil, unless capacity coupling is added. The features of Litz wire, universal winding, and high-impedance primary are retained.

R.F. Coupling Coils

The two types correspond in design and construction to the aerial coils detailed above, and are intended to be used with them.

(1) **Type 55:** This is the air-cored R.F. coil corresponding to aerial coil type 50. It uses a high-impedance primary winding, and is similar in general characteristics to the former coil.

(2) **Type 35:** This is the new dust-cored R.F. coil, intended to work in conjunction with aerial coil type 30. It, too, has the new features of top-capacity coupling and cylindrical iron-dust core.

SHIELDED TYPES

All shielded coils are mounted in aluminium shield cans 1⅜" square by 1½" high. The coils themselves are wound on ½" diameter bakelized paper former but this time the terminating lugs are all mounted at the bottom end of the former. The lugs are arranged to project slightly under the chassis when the cans are mounted on it, so that the lugs make a firm foundation for wiring, without the use of additional terminal strips. The mounting lugs by which the cans are attached to the chassis are riveted to the cans, threaded, and provided with nuts and spring-washers.

Aerial Coils

(1) **Type 10:** These are similar to the unshielded types in general design; they have high-impedance primaries, and are wound with Litz wire. Unlike the unshielded types, however, they have movable iron-dust cores, which, although sealed on leaving the factory, may be adjusted if desired to give a slight range of inductance variation to the tuned secondary winding. This feature is useful where special circumstances require an inductance somewhat different from that needed for standard gang condensers.

(2) **Type 90:** This is the new shielded type employing the new type of dust core. No inductance variation is provided in this type, the core being fixed in position during manufacture.

R.F. Coupling Coils

As in the unshielded series, there are two main types of R.F. coil, each corresponding to one of the aerial coils. As above, they both use high-impedance primaries, and embody built-in top-capacity coupling.

(1) **Type 15:** This corresponds in design to aerial coil type 10; it has the same variable inductance feature as the latter.

(2) **Type 95:** This is the new shielded R.F. coil, and corresponds to aerial coil type 90.

"A" AND "B" SERIES COILS

The above coil types are all subdivided into two sub-types, A for gangs of 420-460 mmfd. max. capacity and B for gangs from 360-380 mmfd.

LABORATORY TESTS ON SOME OF THE ABOVE COILS

In estimating the performance of coils such as the ones under discussion the most practical method is to connect them in a typical receiver circuit and to measure the gain and selectivity at appropriate points. This is because formal measurements of secondary Q, primary inductance, and coefficient of coupling between primary and secondary, cannot easily be translated in terms of stage gain and selectivity, which are the ultimate objects of the coil design.

Accordingly, a circuit was constructed using a 6K7 as a tuned R.F. stage and 6K8 as oscillator-mixer. In addition, a 6SJ7 was wired as a pentode plate detector, with its grid attached to the control-grid of the mixer stage. This tube introduces negligible shunting across the 6K8 input, and acts as a V.T. voltmeter, enabling gain and selectivity measurements to be made while the rest of the circuit is

working in a representative superheterodyne circuit. Arrangements were made to enable the R.F. and aerial coils to be plugged into sockets, so that the set-up could represent receivers either with or without a stage of tuned R.F. amplification ahead of the mixer. Before measurements were made, tests were carried out to ensure that there was no regeneration which could alter the results and give false indications of both selectivity and coil gain. The coils tested were types 90 and 95, and 30 and 35, both pairs being the new types mentioned above.

GAIN MEASUREMENTS

The figures given below refer simultaneously to both pairs of coils, since the results were found to be identical.

Aerial Coil Gain

This was measured using a standard signal generator and a standard dummy aerial, by injecting signal first into the grid of the R.F. stage, and then into the aerial terminal, and adjusting the input so as to give identical outputs in both cases. Results were as follows:—

Types 30 and 90 Aerial Coils:

600 kc/sec.	14 times
1000 kc/sec.	10 times
1400 kc/sec.	8.3 times

These figures indicate a slightly rising coil gain at the low-frequency end of the band, but it should be remembered that a variation as slight as this would not be noticed in practice, and represents a great improvement over similar coils not employing top-capacity coupling. The latter normally show much greater variation of gain than this, indicating that the extra capacity coupling has been well chosen. A slight increase in this coupling might be advantageous, but in view of the increase of capacitative loading that would be placed on the tuned secondary, much more might be dangerous, in that it could cause undue detuning when certain types of aerial are used. It is clear that the iron-dust core has improved the performance of these aerial coils, since the gain is about twice that to be expected in coils of similar design, but using no dust core.

R.F. Coil Gain

Since the signal generator is unable to reproduce the primary load conditions found in practice when an inter-stage R.F. coil is in use, the gain in this case was measured from the grid of the R.F. stage to the grid of the mixer. The figures therefore include the gain due to the R.F. amplifier tube. This is a useful basis of comparison, however, because the figure mentioned, when multiplied by the aerial coil gain, gives the gain of the whole "front end" of the set, from aerial terminal to mixer grid. The figures obtained were as follows:—

Types 35 and 95 R.F. Coils:

600 kc/sec.	66 times
1000 kc/sec.	44 times
1400 kc/sec.	40 times

It will be noticed that, like the aerial coils, the R.F. coils have a somewhat rising gain at the low-frequency end of the band. The same remarks as before apply to the effectiveness of the complex coupling between primary and secondary, except that in this case an increase in capacity coupling would stand more chance of levelling the response even more, without incurring undesirable effects.

SELECTIVITY MEASUREMENTS

The same measuring set-up was used to measure selectivity as for the gain measurements above. Results were as follows, and were identical for the corresponding types:—

Types 30 and 90 Aerial Coils (measured at 1200 kc/sec.):

Freq. off Resonance	Response (Db. Down)
0 c/sec.	0
20 kc/sec.	14 db.
40 kc/sec.	16 db.
60 kc/sec.	18 db.
80 kc/sec.	21 db.
100 kc/sec.	23 db.

Types 35 and 95 R.F. Coils:

0 c/sec.	0
20 kc/sec.	6 db.
40 kc/sec.	12 db.
60 kc/sec.	14.5 db.
80 kc/sec.	17 db.
100 kc/sec.	20 db.

Aerial Terminal to Mixer Gird (either types 30 and 35 in use, or types 90 and 95):

0 c/sec.	0
20 kc/sec.	20 db.
40 kc/sec.	28 db.
60 kc/sec.	32.5 db.
80 kc/sec.	38 db.
100 kc/sec.	43 db.

Little comment is required on these figures, as they speak for themselves. It will be noticed, however, that the aerial coil has considerably more selectivity than the R.F. coupling coil. This is understandable, for if the R.F. coil were designed for maximum selectivity, without regard to other factors, the R.F. stage gain would be drastically reduced. The last table shows how good an image ratio would be obtained in a set using an R.F. stage with these coils, since with the usual 465 kc/sec. I.F. the image is 930 kc/sec. removed from the signal frequency, and, as measured, the response of the R.F. section as a whole is already 43 db. down, only 100 kc/sec. away from the signal.

For sets using only an aerial coil (i.e., no R.F. stage), the figures on the aerial coils alone show that here, too, excellent image rejection can be expected, as well as very good sensitivity.

PHILIPS EXPERIMENTER

(Continued from page 34.)

OUTPUT

The power output of all of the above circuits is strictly limited, as the harmonic oscillator draws only as much as the fundamental circuit. In our opinion, this is no disadvantage, as we have never been among those who think that high power output and extreme stability go together in the same oscillator circuit, and this is especially true of the EF50 when used as an oscillator. Power output is one thing, and stability is another, and the best practice, in both commercial and amateur design, is to separate the two functions as far as possible. Power is easy to get, and once a good oscillator has been made, there is no difficulty in raising the output level to any desired figure, however low the starting point may be. Nor need this philosophy result in a transmitter with a great multiplicity of stages, for with the enormous power-gains that can be achieved now that really satisfactory transmitting pentodes are a reality, there is no good reason for the use of too many valves in a transmitter, however low the oscillator power.

A NEW TRIODE AMPLIFIER

(Continued from page 27.)

has to run a matter of three inches, and might otherwise pick up some hum. Apart from these points there is nothing of great importance in the mechanical side of the amplifier. The circuit lends itself to a good arrangement of parts, and if a reasonably similar lay-out is used, there should be no difficulty in duplicating the performance of the original, which was excellent.

MODIFICATIONS

There is no reason why, if constructors wish, they should not use the voltage amplifier set-up given here to drive any other suitable output tubes. If output smaller than 10 watts is large enough, 45's could be substituted for the 2A3's, the only change necessary being the value of the bias resistor, and of course, the provision of 2.5v. instead of 6.3 for their filaments. Similarly, with the addition of negative feedback, it would be reasonable to replace the 6A3's by pentodes or beam tetrodes. However, this would make further modification essential if the feedback were to be easily applied, and this could well be the subject of a separate article.

NOTES ON H.F. OSCILLATORS

(Continued from page 20.)

better the circuit, so that if a change is made in an experimental circuit, measuring the striking voltage gives a positive indication of whether an improvement has been made or not, as long as the striking voltage of the first arrangement has been found also.

In practice, two methods can be used to find the striking voltage of an oscillator. One of them, however, is more useful than the other, because it has greater practical significance. This method consists in turning on the filament (or heater) and allowing a sufficient time for this to warm up. The plate voltage is now gradually increased from zero until the oscillator starts, when the plate voltage is read. This figure is the striking voltage.

Another important point about the striking voltage is the fact that the lower it is, the greater will be the frequency stability of the oscillator.

CONCLUSION

The above account does not pretend to exhaust the possibilities for experiment when an oscillator tube or circuit is being tried out. It does show, however, the systematic way in which such experiments should be undertaken if the maximum results are to be obtained in the least possible time. Basically, the procedure is to take one thing at a time, make a change, and observe the effect of this. If the change is unfavourable, or has no noticeable effect, the preceding state of affairs is restored, and a different change made. The whole point is that if changes are made at random, or if more than one is made at a time, it is not possible to decide which is responsible for any alteration in performance that may be observed, with the result that it is possible to go round in circles without coming to any useful conclusions at all. These remarks apply equally to any experiment, but are especially applicable to the problem we have been discussing, and to a great number of others connected with radio.

With regard to the results we ourselves obtained with the 1S4 and 1S5, the fact that they will not oscillate with ordinary lumped circuits at frequencies higher than about 136 mc/sec. does not mean that this is their absolute limit. To discover this, they would have to be tried in circuits using open wire or coaxial lines as tuned circuits, not to mention some of the newer developments in the way of high-frequency circuit elements, such as the butterfly and cylinder circuits mentioned above. Also, although we have shown that these valves will not go quite as high as the 144 mc/sec. amateur band in the style of circuit considered, there is no reason why they should not make excellent oscillators at half this frequency, nor yet why the same tubes would not act as doublers to give output on this band. A further point to be remembered is that a given type of valve will act as an amplifier at higher frequencies than its maximum as an oscillator. From the above, it can be seen that any experimental work that an amateur may like to undertake in this line will be amply repaid in the results obtained, if their fullest implications are considered.

QUESTIONS AND ANSWERS

(Continued from page 14.)

point about the layout is that the volume control potentiometer is almost the whole length of the chassis away from the 1S5 detector and first audio tube. Thus, unless the volume control input and output leads are shielded these are ideally situated for picking up I.F. and could easily cause the trouble as originally diagnosed.

ATOMIC ENERGY, ETC.

(Continued from page 6.)

ent problems. Perhaps, instead of being pessimistic, an "ignorance is bliss" attitude would be better. Nevertheless, the realization of the magnitude of the job and the steps being taken to put adequate manpower to work on it give assurance that the necessary research and development will be done and done in as short a time as can reasonably be expected.

TUBE DATA

(Continued from page 31.)

Oscillator Output, at Grid .... 8v. R.M.S.

Capacities:

(a) **Hexode Section—**

Input	3.8 mmfd.
Output	4.7 mmfd.
Plate to Control-Grid	0.1 mmfd.

(b) **Triode Section—**

Grid-Cathode	5.6 mmfd.
Plate-Cathode	1.5 mmfd.
Grid-Plate	1.2 mmfd.

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N.Z. RADIO TRADERS' FEDERATION

(Continued from page 43.)

station to be set up and to operate on regular frequencies."

This was seconded by Mr. Billing and carried.

Mr. Billing then stated that he had unofficial information that station 3YA, 720 kilocycles, is maintained at a sufficient degree of accuracy by the New Zealand Broadcasting Board to be used as a frequency check station within the broadcast band. Servicemen could make good use of this for checking receiver calibration, and signal generator frequency, etc., as from this station a harmonic of the station will appear at the high frequency end of the broadcast band or signal generator set to zero beat with the fundamental, and similar results achieved.

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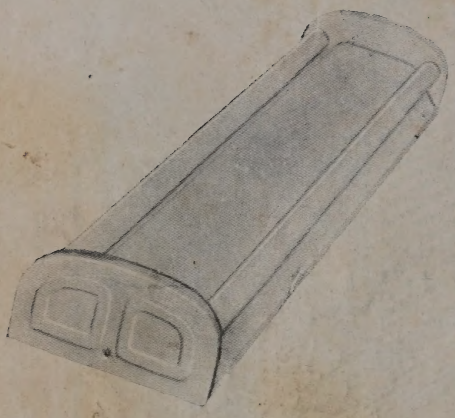

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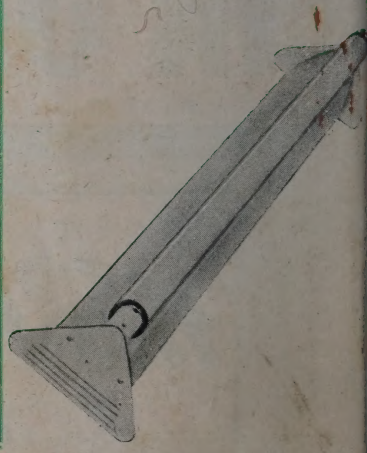

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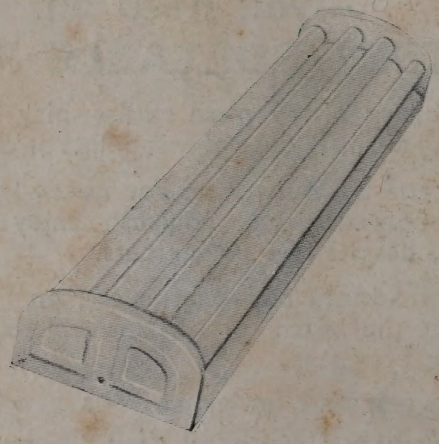

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